How to Win the War on Light Pollution

ASTRONOMY®

Hunting Tiny Stars In the Cosmic Haystack

September 1995 U.S. $3.50
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Can. $4.95

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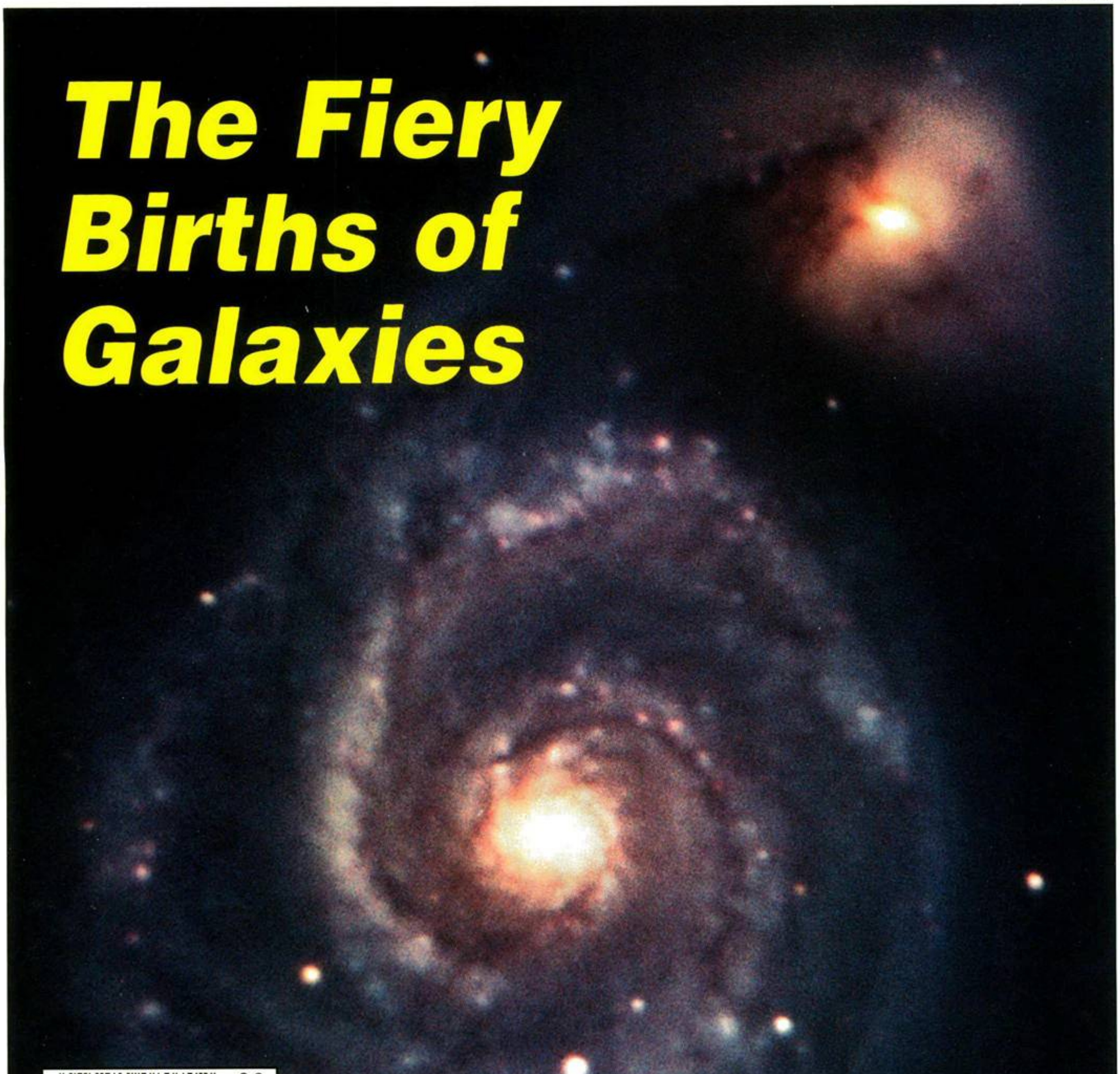

The Fiery Births of Galaxies

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Make Your Scope CCD-Friendly

How to See a New Kind of Deep-Sky Object

MEADE LX200 EMC
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12" LX200
8" LX200
10" LX200
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12" LX200 Schmidt-Cassegrain	**$3995.**

Packing & shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215.

- *All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.
- For dealer or catalog information see the **Meade Starfinder Reflecting Telescope** ad in this issue.

THE TELESCOPE STANDARD OF THE WORLD.

In virtually every country in the world where serious telescopes are sold, more Meade® LX200's are sold than all competing models combined.

In school, college, and university teaching programs, among visual observers, astrophotographers, CCD imaging specialists, and advanced amateurs worldwide, Meade LX200 Schmidt-Cassegrains are, far and away, the Number One choice. No other telescopes offer the LX200's combination of state-of-the-art, standard-equipment features:

■ **Superb Optics:** LX200 optical imaging capabilities are a legend in the industry; we regularly receive user reports to the effect that optical performance approaches that of a fine *ED* apochromatic lens.

■ **Tracking precision:** The LX200's permanently-programmable Smart Drive™ routinely achieves a tracking periodic error of 5 arc secs. or better, the standard for large observatory instruments.

■ **Automatic GO TO capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec. coordinates to a precision of *one arc-minute or better.*

■ **64,350-Object onboard database:** Imagine having 64,350 celestial objects at the tip of your finger: 64,350 objects—galaxies, nebulae, globular clusters, double stars, planets, objects of every description—*that you can center in the telescopic field just by entering and pressing GO TO on the hand controller.* The Meade 64,350-object library includes an incredible array of phenomena, virtually a lifetime of deep-space study, even for the advanced observer:

12,921	galaxies from the Uppsala General Catalog; the complete UGC catalog.
7,840	objects from the New General Catalog; the complete NGC catalog.
5,386	objects from the Index Catalog; the complete IC catalog.
21,815	variable stars; the complete listing from the General Catalog of Variable Stars.
15,928	stars from the Smithsonian Astrophysical Observatory (SAO) catalog of stars brighter than 7th magnitude.
351	alignment stars for the LX200 telescope.
110	Messier objects; the complete listing.
8	major planets from Mercury to Pluto.
64,359	objects, total

LX200

SCHMIDT-CASSEGRAINS

■ **Meade High-Precision Pointing**™ is so precise that it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically. Photographing or CCD imaging faint objects *at or past the visual observing limit (e.g.,* the planet Pluto or a supernova in an 18th-magnitude galaxy) is not only practical, but routine, because of the extreme precision with which the LX200 positions the object on to the CCD chip or in the telescopic field.

■ **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guiding, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.

■ **Field Portability and Operation:** No other telescopes of such sizable apertures and incredible capabilities transport so readily for field operation. Field set-up requires only minutes, and the optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering of the telescope directly from a 12-volt auto cigarette lighter plug.

SPECIFICATIONS: 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel display on the drive base; manual and electric slow-motion controls on both axes; keypad handheld controller with digital readout display, permanently programmable Smart Drive™, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,350-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (for field operation from any 12v. auto cigarette lighter plug, use the Meade #1812 Electronic DC Adapter, a 4-oz. unit available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); complete operating instructions.

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Woodruff Sullivan, University of Washington, and IDA

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How to Beat Light Pollution
The war against light pollution is far from lost. In fact with the help of people like you, the forces of darkness may just be turning the tide. By Robert Bunge.

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Needles in the Cosmic Haystack
Astronomers think the Galaxy should be teeming with brown dwarfs — failed stars too small to ignite the fires of nuclear fusion — but have yet to find more than one good candidate. By Sally Stephens.

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Sky Almanac
The action centers on the two largest planets, with Saturn appearing at its best for 1995 and Jupiter occulting the star Omega Ophiuchi. By Deborah Byrd and John Shibley.

ON THE COVER

LURKING IN THE HEARTS of many nearby galaxies (like the Whirlpool Galaxy seen here), may be massive black holes — the *long-dead engines behind* an earlier, active galaxy phase. For more on active galaxies and what they say about the origins and evolution of galaxies in general, see page 36. Photo by Jason Ware.

Greg Terrence and Ray Ciccariello

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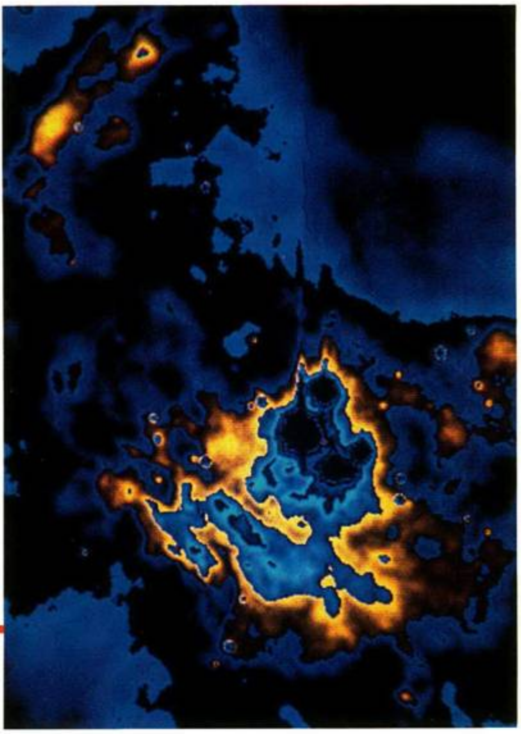
Donald Parker

72 Spotlight on Saturn's Satellites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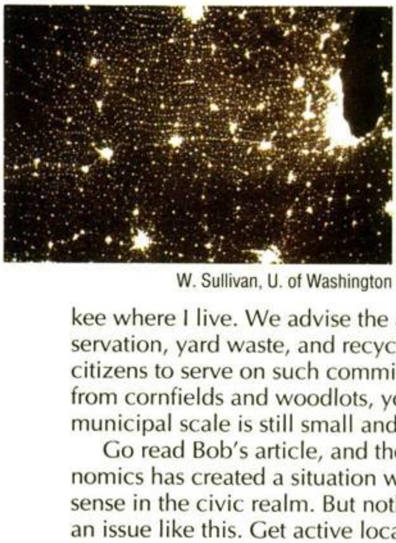
BEHIND THE SCENES

Helping the Forces of Darkness

When you mention light pollution, most backyard astronomers get a hopeless, lost-cause kind of feeling. But while this reaction embodies a kernel of truth, there is actually considerable grounds for optimism. As Bob Bunge reports starting on page 44, important battles have been won by the "forces of darkness" — that's us, the good guys — and moreover, certain economic and social trends are running in our favor. Let me explain.

First, economics. What we call light pollution is, on a civic scale, the same as tearing up dollar bills. Faced with voters' concerns over rising property taxes, every municipality is looking to save on utility costs. (As are private companies, which explains why many are starting to shut off their lights at 11 pm or so.) When fixtures are designed to put light only where it's wanted — and this usually excludes the sky — they are cheaper to operate.

Our **backyard from above**


W. Sullivan, U. of Washington

Next, society. Despite some back-to-the-city movement, most North Americans are buying houses in suburban tracts chopped out of rural land. This can eat into dark skies, but it also puts many more people's homes where they can enjoy (and hopefully, preserve) a rural sky. I say "hopefully," because preservation isn't universal or assured.

Which brings up my final point — your involvement as a citizen and backyard astronomer. I serve on a citizens' committee in the suburb of Milwaukee where I live. We advise the administration and elected officials on matters of conservation, yard waste, and recycling. Municipalities are always looking for concerned citizens to serve on such committees. If you've moved into some new town sprung up from cornfields and woodlots, you have a perfect chance to get involved because the municipal scale is still small and manageable.

Go read Bob's article, and then get involved in your community. Right now, economics has created a situation where we can align our interest in dark skies with good sense in the civic realm. But nothing's guaranteed, and there are no lasting solutions in an issue like this. Get active locally and do it soon.

Sincerely,

Robert Burnham
Editor
rburnham@astronomy.com

LETTERS

Surfin' the Astronet

Thanks for your article "Blasting Along the Infobahn" (June 1995). I am really hooked on the Internet. Last summer when Comet Shoemaker-Levy 9 crashed into Jupiter I was able to get pictures off the Internet just hours after they were taken. Our organization held a public event attended by over 400 people and we were able to show them pictures taken the day before with some of the world's largest telescopes. Then they could go outside and see the spots for themselves in our telescopes. It was a very exciting night, made all the better by the Internet. — *Dave Weinrich, Moorhead Regional Science Center, Moorhead, Minnesota, weinrich@mhdl.moorhead.msus.edu*

In the past 24 hours I've jumped into a completely new universe! The arrival of my June ASTRONOMY coincided perfectly with the delivery of *CompuServe Magazine* and WinCam 1.4/Mosaic software. I simply combined the CompuServe Web access and the Internet information provided by you and presto — I was looking at the Keck telescope's viewing schedule along with many other exciting things.

I hope amateur astronomers keep an open mind about online astronomy, too. The CD-ROM and online information available today enhance the whole experience for me. I can keep an eye on what the pros are discovering almost daily and then go out in my backyard observatory to look at the same objects. — *Ken Randall, randall_ken@westpoint.ccmail.compuserve.com*

Thanks for the article. I got interested in the Internet because of astronomy. The first file I downloaded was a zipped file of the Moon and planets. I hope many of your readers learn a lot from the Net. And check out my Home Page at

(continued on page 14)

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TELESCOPES AND ACCESSORIES

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (3.29)

Series 4000™ Super Plössls 52°

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers--a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$87.95**	(3.45)
32mm (52°); **40mm** (44°)	each:	**109.95**	(3.79)
56mm (52°; 2")		**229.95**	(5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25"

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000™ Super Wide Angle 67°

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $159.95** (3.49); **18mm: 169.95** (3.69); **24.5mm: 199.95** (3.89); **32mm** (2"): **279.95** (4.78); **40mm** (2"): **339.95** (5.48)

Series 4000™ Ultra Wide Angle 84°

The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Meade Model 285 60mm f/15 Equatorial Refractor

Complete with tripod and 2 eyepieces.

Includes the same equatorial mount of larger Meade models at right. Dual-axis worm-gear slow-motion controls permit easy tracking of astronomical objects. Two eyepieces (1.25") for powers of 36X and 100X. Multi-coated objective lens resolves to the theoretical limit.

Accepts #531 Motor Drive *(below)*

$299 (16.55)

Meade Model 4500 4.5" f/8 Equatorial Reflector

World's largest-selling 4.5" telescope!

The finest first-telescope available. *Provides stunning optical performance on the Moon, planets, and hundreds of deep-space objects.* Precision equatorial mount includes worm-gear slow-motion controls in RA and Dec and full-length (50") aluminum tripod. 6 x 30 finder, rack-and-pinion focuser (1.25"), multi-coated MA 25mm eyepiece (1.25"). *Immediate delivery through your authorized Meade dealer.*

Fully automatic tracking with #531 Motor Drive *(below)*

$399 (22.40)

Meade Model 390 90mm f/11 Altazimuth Refractor

Perfect for land-viewing or astronomy.

Excellent imaging power for any terrestrial application, or for observing hundreds of astronomical objects in sharp detail. Smooth dual-axis controls; multi-coated optics. Supplied with 6 x 30 finder, MA25mm eyepiece (1.25"), aluminum tripod.

Includes flexible steel cable controls on both axes.

$499 (23.60)

Meade Model 395 90mm f/11 Equatorial Refractor

Multi-coated, high-resolution optics.

Includes flexible steel cable controls on both axes.

Accepts #531 Motor Drive *(below)*

Precision Meade objective lens far surpasses other telescopes selling at similar prices. Complete with equatorial mount, aluminum tripod, 6 x 30 finder, MA 25mm eyepiece (1.25"). Thousands now in use.

$599 (24.65)

Meade intermediate-size telescopes are the world's largest-selling quality telescopes of their apertures. *They are the only telescopes in this price range designed by Meade engineers and manufactured to exclusive Meade specifications.* Each instrument includes mechanical components, gear systems, and accessories specifically intended for serious applications of the beginning to intermediate amateur astronomer. American-size 1.25" barrel-diameter eyepieces, threaded for filters, are included with all models. Large cable controls facilitate the tracking of astronomical or terrestrial objects, and, on equatorial models, the optional Meade #531 Motor Drive *(see right)* enables fully automatic tracking of astronomical objects.

#531 Motor Drive

Attaches in seconds to the equatorial mounts of Meade Models 285, 4500 or 395 telescopes. Permits fully automatic tracking of celestial objects. Cordless operation anywhere in the world from 3 (user-supplied) AA batteries. **$99.50** (4.78)

Series 3000™ Plössls 50°

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

Series 3000™ Plössl 40mm 44°

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°.

MA 9, 12, 25, 40mm. each: **$37.95** (2.98)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25". **$59.95** (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, at right. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

HOW TO ORDER

- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders: 800-843-4780; Info.: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Info/IL: 312-332-2000.

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EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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8" f/6
$425.

6" f/8
$325.

Shown with optional #637 6 x 30mm or #545 8 x 50mm Viewfinders

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At the time you order any Starfinder 6", 8", 10", 12.5", or 16" Dobsonian Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces *and* the Meade #637 6 x 30mm coated achromatic viewfinder with metal bracket for a *total* of only $49.95! Purchased separately, the 2 additional eyepieces and viewfinder sell for $125.85!** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces, with #637 6 x 30mm viewfinder.)* Offer valid until further notice.

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Immediate shipment!

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Includes 1.25" rack-and-pinion focuser; shown with optional 8 x 50mm viewfinder.

Compare Meade Starfinders *feature-for-feature* with other similarly priced Dobsonians!

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- **Precision Rack-and-Pinion Focuser!** An industry-standard full-size rack-and-pinion system with 2.6" of focus travel.
- **Fully-Adjustable 4-vane Secondary Mirror Systems!** *Rigid 4-vane systems* that permit precision alignment of the secondary mirror to the primary mirror.
- **Rigid, Durable, Beautiful Dobsonian Mountings!** Mountings that provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the location and tracking of celestial objects anywhere in the sky. Each mount is manufactured of cabinet-quality materials and designed for a lifetime of use. Handles are provided for easy portability.
- **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(facing page)*. All telescopes include a multi-coated MA25mm eyepiece as standard equipment. Each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.
- **Performance!** A Meade Starfinder Dobsonian or Equatorial Telescope opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects–nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space astrophotography.
- **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$39; 8"–$49; 10"–$69; 12.5"–$79. 16"–$45 packing, shipped truck freight collect.
- **To Order:** Contact one of the authorized mail-order dealers on the facing page.

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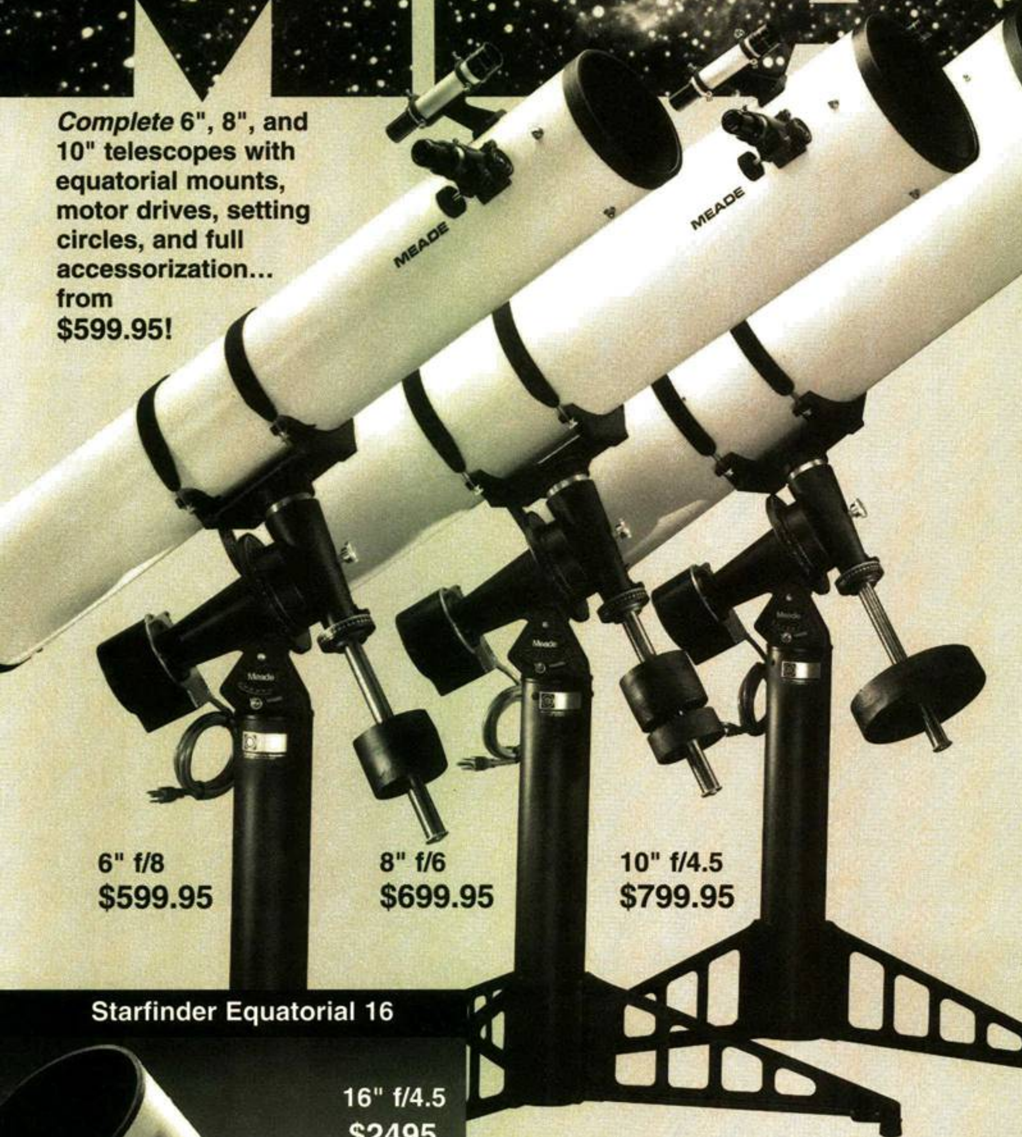
***Complete* 6", 8", and 10" telescopes with equatorial mounts, motor drives, setting circles, and full accessorization... from $599.95!**



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- **Electric Motor Drive** (115v/60Hz) with 6 ft power cord: permits **fully automatic** tracking of celestial objects; plugs into any standard outlet.
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- **Optional Accessories:** See the Meade accessories ad in this issue. Additional systems, including #55 Manual Declination Control, #43 Drive Corrector, and #47M Dual-Axis Drive Corrector, are described in the Meade General Catalog.

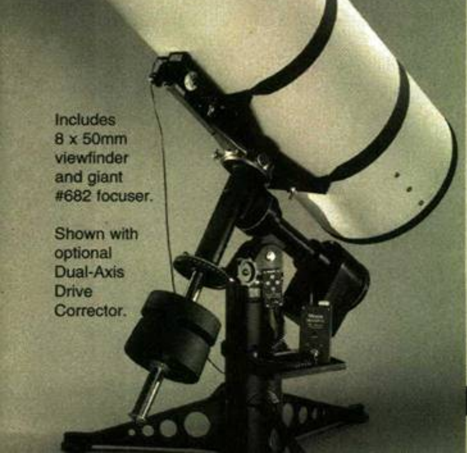
SPECIAL ACCESSORY OFFER! At the time you order any Starfinder 6", 8", 10", or 16" Equatorial Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces for a *total* of $29.95! Purchased separately, the two additional eyepieces sell for $75.90.** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces.)* Offer valid until further notice.

- **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$65; 8"–$75; 10"–$90. 16"–$55 packing, shipped truck freight collect.
- All prices shown are suggested USA mail-order retail prices, not including any applicable sales taxes.
- **Meade 1995 General Catalog** — $3.00 postpaid—is available from any authorized Meade dealer or directly from Meade Instruments.
- For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:

Starfinder Equatorial 16

16" f/4.5
$2495.

See the Meade General Catalog for details.



Includes 8 x 50mm viewfinder and giant #682 focuser.

Shown with optional Dual-Axis Drive Corrector.

Standard equipment on 6", 8", and 10" models includes:

- **Superb Optical System:** Includes hand-figured parabolic primary mirror that meets the theoretical limit of resolution for its aperture, with matching elliptical flat secondary mirror. Both mirrors multi-coated and made of low-expansion, Grade A, fine-annealed Pyrex® glass.
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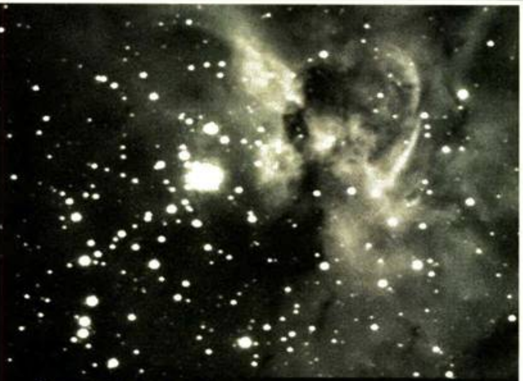
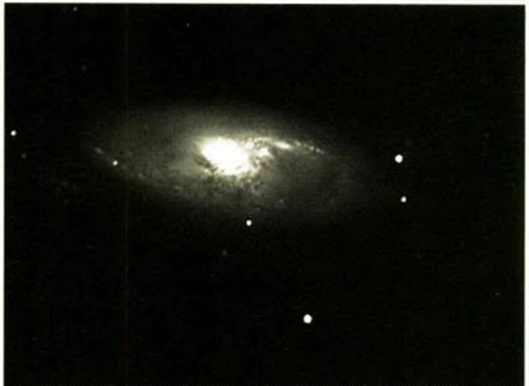
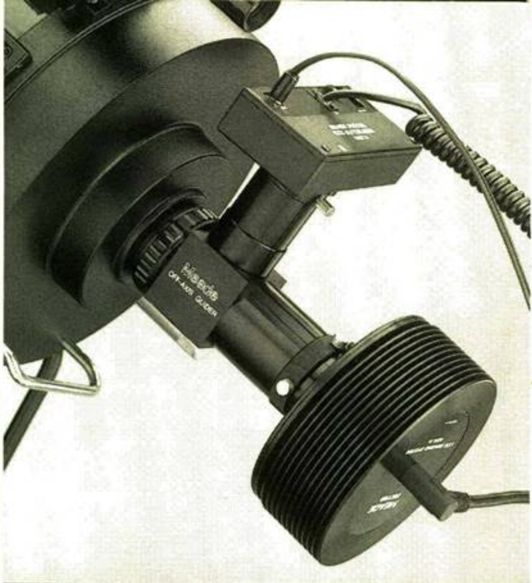


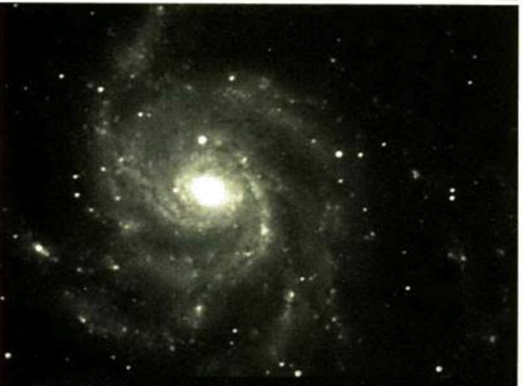
Pictor 416 image by Steven Williams of the Keyhole Nebula. Exposure: 5-mins. Meade 10" f/10 LX200 Schmidt-Cassegrain.



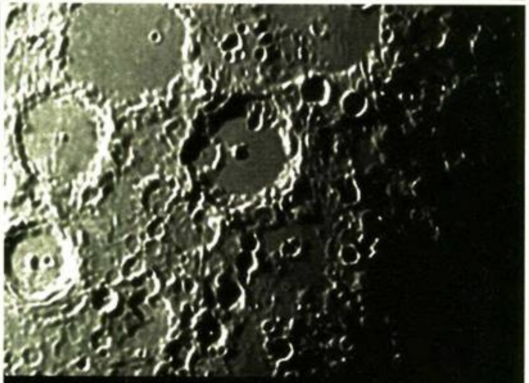
A 10-minute exposure of M106 in Canes Venatici by Jack Newton, using the Pictor 1616 with a 25" f/5 Newtonian reflector.



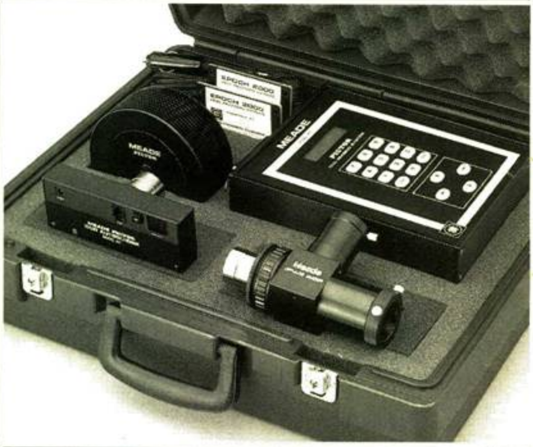
CCD imaging is **automatic** with a Meade Pictor Imager. And, for a limited time, when you purchase the Pictor 416 at $2495 or the Pictor 1616 at $6995, we'll pack it with the $800 Meade CCD Equipment System *(below)* **at no additional charge.** Use the Pictor 201 and CCD Off-Axis Guider *(above)* to autoguide your Pictor 416 or 1616— or your 35mm camera during astrophotography. No other autoguider/imager system is so flexible and so easy to use.

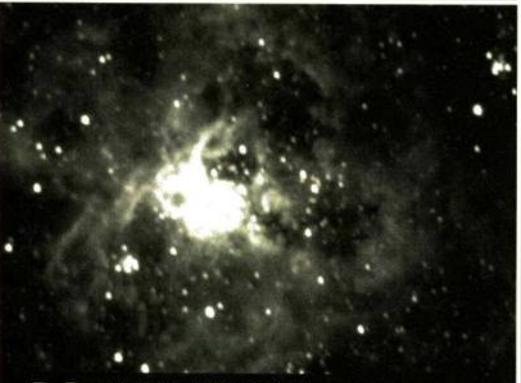


Pictor 1616 image of Spiral Galaxy M101 by Jack Newton. 25" f/5 Newtonian; 10 minute exposure.

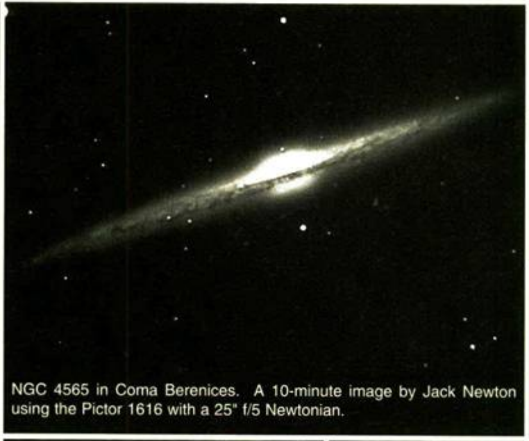


Alphonsus/Ptolemaeus region of the Moon. Imaged by Steven Williams. Pictor 416 for 1/10 second. Meade 10" f/10 LX200 SCT.

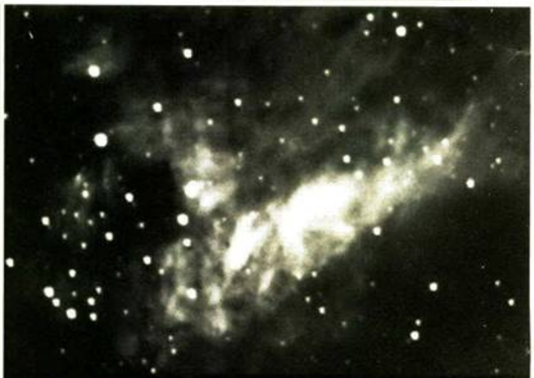




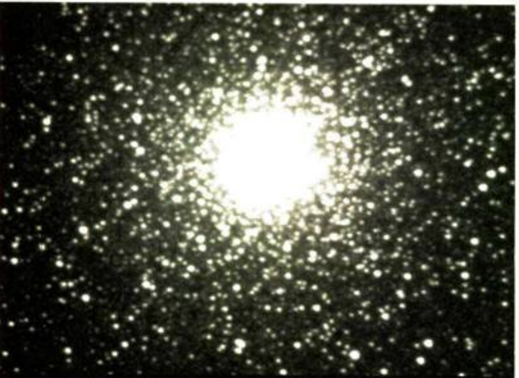
The Tarantula Nebula (NGC 2070). Pictor 416; 4-minute exposure by Steven Williams; Meade 10" f/10 LX200 Schmidt-Cassegrain.



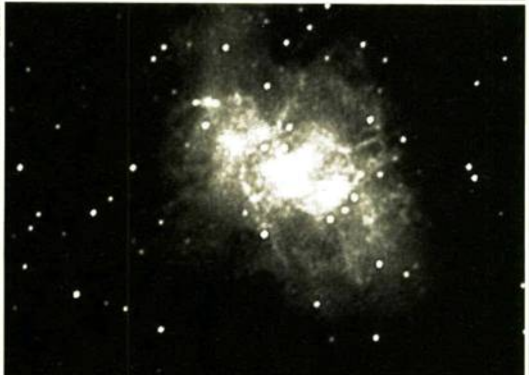
NGC 4565 in Coma Berenices. A 10-minute image by Jack Newton using the Pictor 1616 with a 25" f/5 Newtonian.



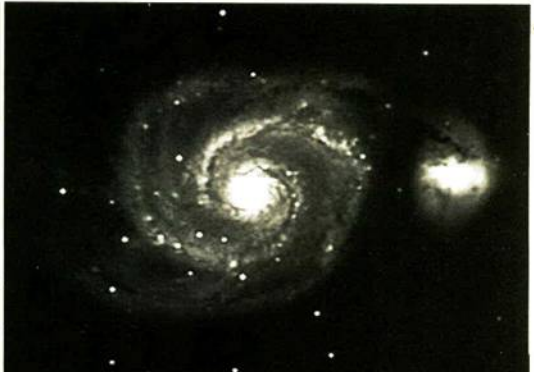
The Omega Nebula (M17). A 3-minute unguided image by Ron Ezra. Meade 10" f/10 LX200 Schmidt-Cassegrain and Pictor 416.



Globular Cluster 47 Tucanae. Imaged by Steven Williams for 3-minutes. Pictor 416 with a Meade 10" f/10 LX200 SCT.



A 10-minute Pictor 1616 image of the Crab Nebula (M1) by Jack Newton, using a 25" f/5 Newtonian reflector.



The Whirlpool Galaxy (M51) in Canes Venatici. Imaged by Jack Newton; Pictor 1616 and 25" f/5 Newtonian; exposure: 10-mins.

"We couldn't believe what we were seeing. We attached the Pictor 416 to my 8" LX200 and a few minutes later there on the PC display was an observatory-quality image of the Whirlpool Galaxy M51..."

"We continued to object-hop around the sky. The Owl Nebula (M97), four spiral galaxies in Ursa Major (M81, M94, M101, M108), the Hercules globular cluster (M13), two spiral galaxies in Canes Venatici (M63, M94). In about an hour we imaged over a dozen objects! The Pictor 416 displayed them all with a level of structural detail and resolution that we had seen before only in long-exposure photographs. And every image was quick, easy, no-hassle. Your ads are correct: the Pictor 416 is one awesome imaging camera."

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Pictor 201 Autoguider: For flawless, ultraprecise autoguiding during long-exposure astrophotography or CCD imaging. Automatically locks on to guide stars as faint as 10th-magnitude and makes all required dual-axis corrections. Results in perfectly guided astrophotographs or CCD images during even the longest of exposures. Completely self-contained; no host PC required. **$395.** + $10 packing & shipping in 48 states.

Pictor 208 Autoguider/Imager: For an amazingly low price, the 208 gives impressive imaging capability even to the novice. On telescopes of 4" aperture and larger, the Pictor 208 yields very satisfying results and, in addition, is a full-capability autoguider, containing the exact same autoguider hardware and software as the Pictor 201, above. The 208 incorporates the Texas Instruments TC-255 microchip, by far the largest, highest-resolution chip available in any CCD unit it its price range. **$795.** + $15 P & S

Pictor 216 CCD Autoguider/Imager: Identical in operation and size to the 208, the Pictor 216 includes a 16-bit A/D converter for 65,536 brightness levels. The result is a level of image quality only obtainable on competing units that sell for almost twice the 216's price. Combining high-resolution imaging with low dark current, the Pictor 216 satisfies the long-term CCD imaging requirements of the majority of serious amateurs.

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Pictor 416 CCD Autoguider/Imager: Armed with the powerful Kodak KAF-0400 CCD microchip, the Pictor 416 is the most advanced high-resolution CCD system available under $5000. And, with its standard-equipment SCSI interface, the 416 can full-frame download in *one second!* The Pictor 416 is a powerful CCD system on any telescope; attached to a Meade LX200, its capabilities are truly awesome. The auto-mosaic feature, for example, permits the imaging of an arbitrarily large sky area **automatically** on user command.

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Pictor 1616 Autoguider/Imager: For professional-level applications the Pictor 1616 utilizes the Kodak KAF-1600 microchip, one of the largest (13.80 x 9.20mm) CCD chips in commercial production. Identical in pixel density and dark current to the 416, but with *four times* the chip area, the 1616 permits the imaging of very large sky areas: a sky area of 23' x 15' with an 8" f/10 Schmidt-Cassegrain, almost one-half the lunar surface in a single exposure. The 1616 is the finest CCD imaging system available at under-$10,000. **$6995.** + $40 P & S

FREE! $800 Meade® CCD Equipment System with purchase of a Meade Pictor 416 or 1616 CCD Imager!

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For a limited time, when you purchase a Meade Pictor 416 or 1616 CCD imager at the regular price, **we'll include an $800 Meade CCD Equipment System —everything you need for advanced CCD imaging—absolutely FREE!** Purchased separately, the CCD Equipment System is priced at $807 and includes the following important products *(see photo, above, and opposite page):*

Meade Pictor 201 Autoguider: Allows completely automatic guiding of your Pictor camera during CCD imaging or your 35mm camera during long-exposure astrophotography.	**$395.**
Meade CCD Off-Axis Guider System: Complete with adapters for 1.25" eyepiece holders and for Schmidt-Cassegrain rear-cell threads. Use with the Pictor 201 on guide stars to 10th-magnitude.	**119.**
Meade CCD Image-Orientation Adapter: Threads into the Off-Axis Guider and permits precise image orientation on the CCD chip.	**35.**
Meade Epoch 2000® Image Processing Software: Professional Windows-based image processing that permits the enhancement and analysis of CCD images using the most advanced techniques, including dynamic scaling, histogram equalization, image convolution, unsharp masking, median filtering, and RGB merging.	**199.**
Meade Foam-Lined Carrying Case (19" x 14" x 7"): Provides for secure storage and transport of your Pictor 416 or 1616 CCD imager as well as all items of the CCD Equipment System described above.	**59.**
Total price of all items if purchased separately:	**$807.**

This special CCD Equipment System offer is effective beginning July 20, 1995, at participating Meade dealers in the U.S.A. and Canada. *This offer is valid until further notice and may be withdrawn at any time.* ■ All prices shown are suggested U.S. national mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable. ■ *For safety reasons AC-powered personal computers should be used indoors only. ■ The Meade brochure ***CCD Imaging Made Simple*** is available free of charge, or send $3.00 for the 76-page **Meade *1995 General Catalog.***

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LETTERS

http://falcon.cc.ukans.edu/~kdayton. It contains links to some excellent astro resources that the article didn't list.

I love ASTRONOMY, and have used it to teach astronomy to my son's first-grade class. Even though they can't read very well, they always grab ASTRONOMY magazines when they have a chance for "silent reading." — *Kim Dayton, University of Kansas, Lawrence, kdayton@falcon.cc.ukans.edu*

That was a great article — concise, helpful, and comprehensive. I hope you will continue covering the Internet in future issues. — *Jeff Hunt, jhunt@eagle1.eaglenet.com*

In Defense of the Organic Detector

I've sat on the sidelines over the last year as readers have debated the merits of the new technologies that are becoming available. But the last wave of letters, especially Jim Whitehouse's snide comment about "square stars" from CCDs, has motivated me to bring my pen into the fray.

Amateur astronomy is becoming as partisan as the Federal government.

John C. Sellechio
Warwick, Rhode Island

As a lifelong devotee of the night sky, the eyeball is still my favorite observing tool. Last year I finally managed to earn the shekels necessary to purchase my first "real" telescope, a 4.5-inch reflector, followed by a 10-inch computerized SCT. My current plan is to add an autoguiding CCD imager. However crude the images are compared with traditional photography, it won't be long before the price and resolution equal or exceed the conventional emulsions (and in less time than the photographic days of Mathew Brady).

Even though I'm voting with my wallet, these new devices don't prevent me from grabbing my jacket and going out to simply enjoy the stars by eye alone. While I admit the first time I found the Ring Nebula with my little reflector I felt a sense of accomplishment, the accomplishment was mundane. Now I spend my time looking at objects rather than looking for them.

New technologies always seem to spur a negative reaction from some folks. Perhaps they feel threatened by the challenge of learning something new. And believe me, I come from a background of poverty, so I'm sensitive to the arguments about pricing young astronomers out of the game. But a glance through the catalogs shows tons of low-cost tools available, all more capable than the eyeball alone. If the love of the night sky is there, I'm sure even the "techno-Neanderthals" would agree that it doesn't matter what you use to observe it. — *Arthur McCloud, newdaymusic@delphi.com*

Stop it! We all share a love of the night sky. Whether we use CCD cameras, equatorial-driven 20-inch Newtonians, or star-hop with 60mm refractors, we are exploring the heavens and deepening our appreciation for the universe. Amateur astronomy is becoming as partisan as the Federal government. — *John C. Sellechio, Warwick, Rhode Island*

Flashing for a Purpose

Reader Ron Harvot does have a legitimate complaint in his frustration with the white flashing strobes on towers (Letters, June 1995). As an amateur astronomer I can well sympathize with his complaint.

As a private pilot, however, I can think of two uses for the strobes: to tell me where those towers are (even when I should not be flying that low) and as a friendly beacon to guide by.

The problem with Harvot's suggestion of red beacons is that they are not readily visible against a backdrop of city lights. Unlike the astronomer, who is looking up, the pilot is looking down on that light, and the red beacon loses visibility in such a circumstance.

Perhaps the thing to do is to use red beacons in rural areas or those where city lighting falls below a certain level. Of course the FAA, the FCC, and state, county, and local commissions would all have something to say about it. I do hope a balance can be worked out. — *Stuart Home, Fresno, California, WB6VRJ@aol.com*

Hot New Film Not So Hot

My interest was piqued when I saw "A Hot New Film for Astrophotos" on the cover of the May 1995 issue. The hot new film, Ektachrome P1600, does appear to respond better than Scotch-Chrome 400, as the article demonstrates, but I wonder how many astrophotographers are aware that 3M downgraded the quality of ScotchChrome 400 a year after its introduction.

Dissatisfied with the performance of ScotchChrome 400, last year I contacted Ed Methuin at 3M. After shooting some test exposures and sending them off to Mr. Methuin, he confirmed my suspicions: In 1993, 3M changed the emulsion and the new 400 was inferior. Sadly, their more promising astrophotographic film, ScotchChrome 800/3200P, was discontinued.

So the current version of Scotch-Chrome 400, referred to in the article, is not the film tested in your original article in 1992. — *Jack Szymanski, Clinton Township, Michigan*

Herschel Club Awards

Tom Polakis described his observations of the 400 brightest Herschel objects nicely (June 1995). Tom, and anyone else, can receive a certificate and a lapel pin after completing these observations.

The Astronomical League, a federation of astronomical societies, awards these certificates and pins to any observer who is a member of the League either through one of the League's 200 local clubs or as a member-at-large.

To receive a booklet listing the specific 400 Herschel objects required for the award and how to record observations, send $6 to the Astronomical League Sales Office, 1901 South 10th Street, Burlington, IA 52601. Beginners with telescopes might prefer to start with *A Guide to the Messier Objects*, available for the same price.

For a list of Messier objects visible with only a pair of binoculars, send a SASE to John Wagoner, 1409 Sequoia, Plano, TX 75023. Certificates and pins are also awarded for both binocular and telescopic observations of Messier objects. For more information on any of these programs, contact me. — *Sue Wheatley, Astronomical League Publicity Chairman, 950 Brandywine, Beaumont, Texas 77706* ☐

ASTRONOMY welcomes feedback. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or letters@astronomy.com. Letters may be edited for length and clarity.

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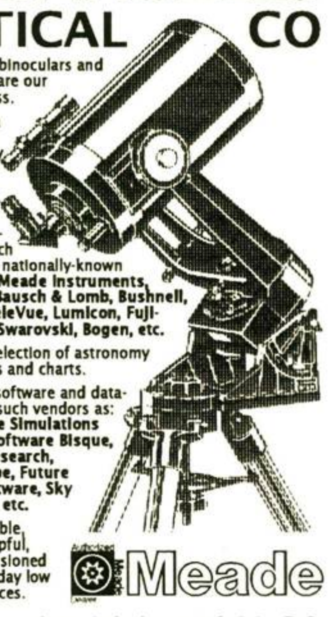

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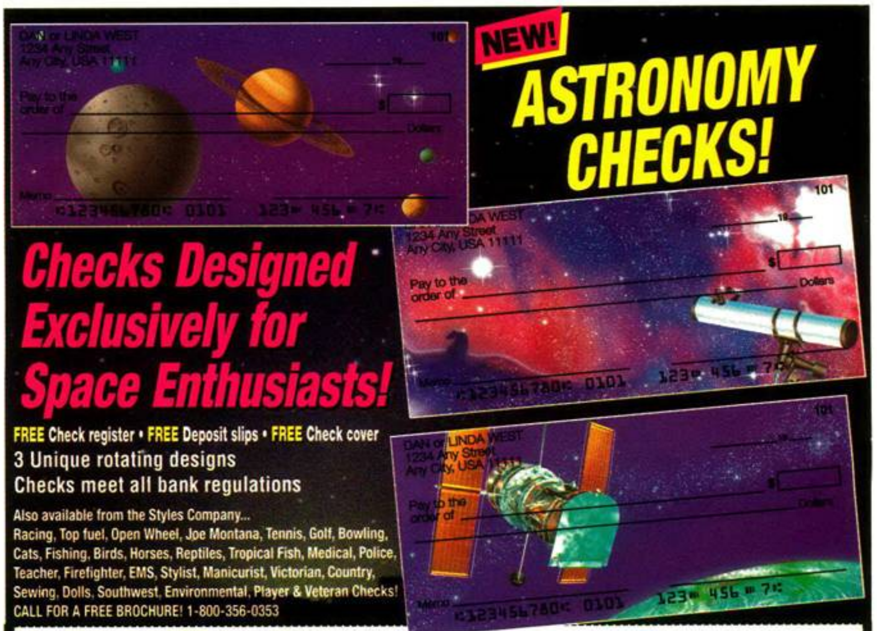

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ASTRO FORUM

Standing on the Shoulders of Giants

by C. Renée Beveridge

> "If I have seen farther than other men, it is by standing upon the shoulders of giants." — *Isaac Newton*

There's an antique shop not far from where I live. I love to browse through it and marvel at the household items produced in an age before me, my parents, and my grandparents. Before automobiles, before E=mc^2, before the Russian Revolution.

Not long ago, in this same small-town antique shop, I happened upon a treasure trove: A room filled with antique books, including two astronomy textbooks, one from 1866 and one from 1902.

They were priceless in my mind, so I left the store that day gingerly cradling my two windows into the past. As I turned the musty pages, I was amused, awestruck, and enlightened.

It's all very well for modern-day teachers to announce quite casually that Mars is uninhabited and that M31 is the Andromeda Galaxy, an entity quite separate from our own Milky Way Galaxy. I've accepted these basic tenets for as long as I can remember.

But in 1866, M31 was the Great Nebula in Andromeda, a spiral nebula within our own cluster of stars. And observers thought they saw little green seas and brown continents on Mars. Many concluded that life probably existed there.

Observers also noted the presence of temporary stars, which seemed to pop up all over the sky from time to time. The 1866 text, *Elements of Astronomy for Schools and Academies* by John Brocklesby, A. M., Sheldon and Company, New York, harkens back to a day in late 1572 when Tycho Brahe noticed a star that didn't exist previously. This temporary star grew brighter until it could be seen in broad daylight. A month later it began to fade, and 16 months later the star was gone completely.

What was this strange temporary star? In 1866, astronomers had no explanation. They simply knew that it happened.

In 1866, they thought sunspots were cavities in the Sun's atmosphere through which the real, dark, solid surface of the Sun could be seen. They thought that Saturn's rings were liquid.

In 1866, they had discovered a grand total of 85 asteroids, the planet Uranus was called Herschel, and Jupiter had but four moons. The list goes on and on.

I found it amusing to read the last paragraph of this antique text: "For with all our surprising discoveries, we are yet upon the very threshold of creation . . ."

They probably didn't realize just how true that statement was. Their "surprising discoveries" are, today, as mundane as knowing Earth orbits the Sun.

Now let's journey into 1902 and see what answers have been found, what surprising discoveries have been made, what forward leaps have occurred.

As for the Great Nebula in Andromeda, one notable improvement is the introduction of its photograph, but still no clues are offered as to its true nature. In 1902 it's just a nebula like all the other fuzzy patches in the sky.

There is even a page in the 1902 text, *Manual of Astronomy: A Text-Book* by Charles A. Young, Ph.D., LL.D., The Athenaeum Press, Boston, displaying striking black-and-white photos of the Pleiades and its enveloping nebula; the Great Nebula in Orion; the "Annular" Nebula in Lyra; and the Whirlpool Nebula. Could the author have found more distinctly different cosmic entities to lump into the same group?

> In 1902, one theory held that temporary stars were not fully coalesced, and every now and then pieces of the star rammed into one another.

One major improvement did evolve between 1866 and 1902: the development of spectroscopy in determining the physical characteristics of objects.

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patterns, Andromeda remained stubborn. It displayed only a continuous spectrum, unmarked by spectral lines of any kind. Modern spectroscopists would regard the data as evidence of the superposition of billions of stellar spectra, but in 1902, Andromeda was simply a puzzling nebula that defied explanation.

How about Mars — was it still inhabited in 1902? More so. Percival Lowell had come on the scene since 1866, and he had observed a vast network of "canals" indicating, at least to him, the presence of Martian intelligence. His sketches take up pages of this text as does his hopeful sentiments that life, indeed, exists on the Red Planet.

> In 1866, they thought sunspots were cavities in the Sun's atmosphere through which the real, dark, solid surface of the Sun could be seen.

Certainly they discovered the nature of those "temporary stars" in the 36 years since 1866, didn't they? Well, no. Unlike the astronomers of 1866, however, they did have some theories.

One theory held that temporary stars are not fully coalesced, and every now and then pieces of the star ram into one another. Another is that they are great eruptions, like solar prominences on a much grander scale. Perhaps not great theories, but theories nonetheless, and a considerable improvement over simply stating their existence.

> In 1866, M31 was the Great Nebula in Andromeda, a spiral nebula within our own cluster of stars.

Despite these shortcomings, it's only fair to mention the more significant advances that had occurred. By 1902, astronomers realized that Saturn's rings were not solid or liquid but a "flock or swarm of separate particles, little moonlets."

By 1902, they'd found another moon of Jupiter, the planet Uranus had its modern name, and nearly 500 asteroids had been detected.

By 1902, they had found through spectroscopy that sunspots were darker

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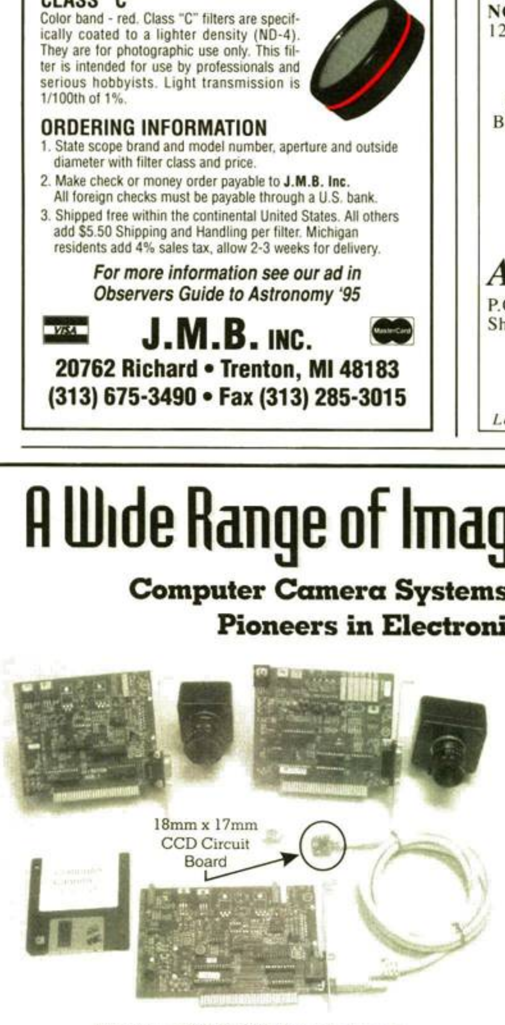

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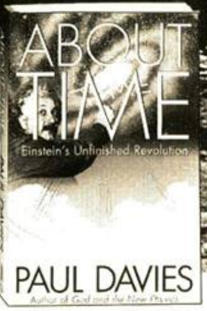

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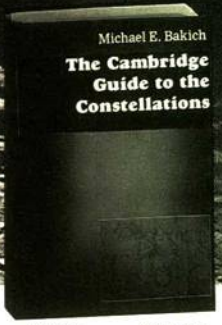

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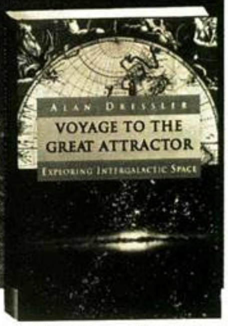

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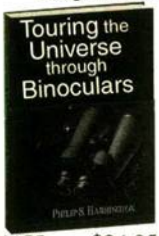

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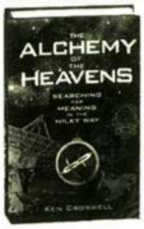

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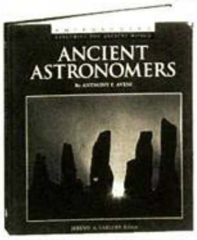

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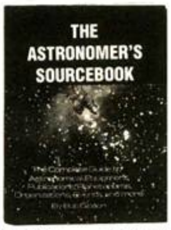

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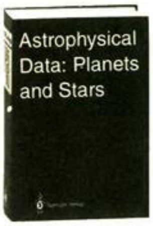

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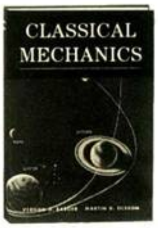

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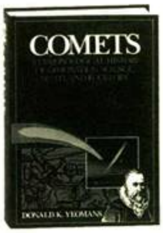

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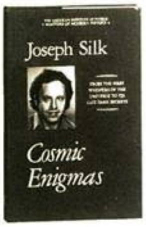

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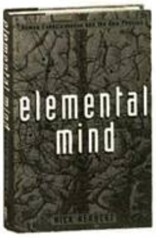

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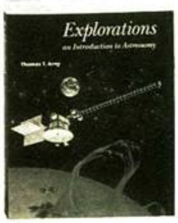

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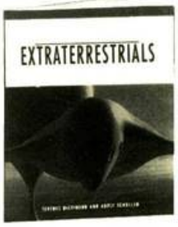

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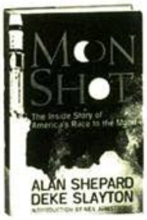

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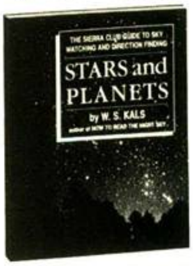

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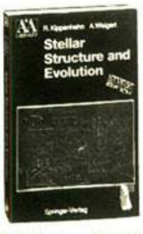

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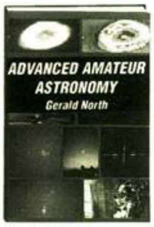

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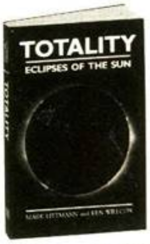

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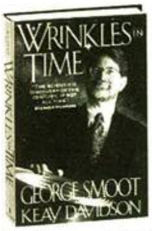

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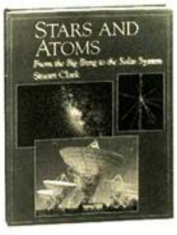

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than the rest of the Sun because light was being absorbed by material above the emitting material. Spectroscopy had even yielded evidence that sunspots and prominences were gases in motion.

It's actually pretty good for nearly century-old scientific research, if you think about it. Instead of simply cataloging heavenly phenomena, astronomers then were making genuine advances in explaining what they saw. Astrophotography and spectroscopy had become commonplace tools for astronomers, and theories, no matter how bold or inane, were being put forth and rigorously tested.

> In 1902, one theory held that temporary stars were great eruptions, like solar prominences on a much grander scale.

I found some of their superannuated theories charming in hindsight. The problems they had with classifying the Great Nebula in Andromeda and the canals on Mars, the enigma of temporary stars, and the question, "Why are nebulae like Andromeda found almost exclusively above and below our plane of stars?" These days, even the occasional dabbler in astronomy could answer many of the puzzling questions of these bygone eras.

But it makes me wonder, especially as I flip through the comparatively current astronomy magazines and read such wondrous titles as "Mysterious Rings Circle Supernova 1987A," "Pulsar Planets Confirmed," and "Milky Way Is Devouring Nearby Galaxy," in 100 years or less will amateur astronomers look back on those headlines and roll with laughter? "Mysterious rings," they may scoff. "Why we all know what those are." And the answer will be as trivial to them as knowing that Earth is a sphere.

Just remember, people once thought Earth was flat, and that the Andromeda Galaxy was a nearby nebula.

And even today we can still say with some confidence that "with all our surprising discoveries, we are yet upon the very threshold of creation . . ." ☐

C. Renée Beveridge is an astronomy enthusiast living in Austin, Texas.

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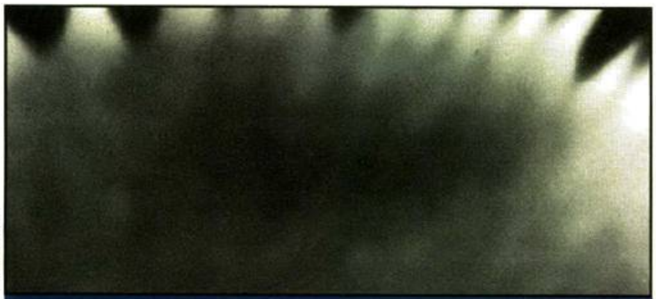
ASTRO NEWS

Neptune's Capricious Clouds

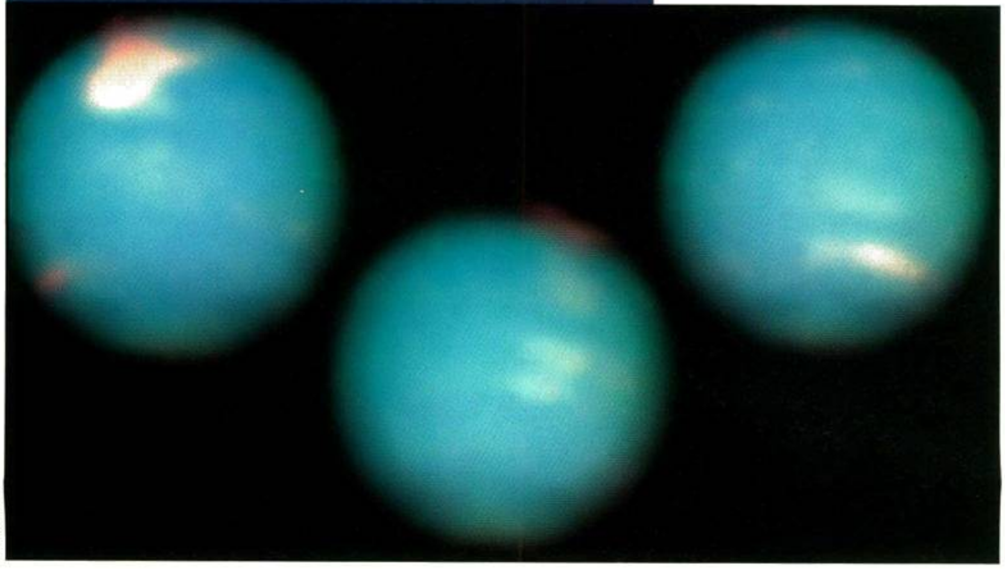
First they're here, then they're gone, then they reappear. Voyager 2 revealed Neptune's Great Dark Spot, a storm system in the southern hemisphere as large as Earth. But when the Hubble Space Telescope took another look in 1994, the spot had vanished. In these new Hubble infrared snapshots of Neptune, a new dark spot has emerged in the northern hemisphere. "Hubble is showing us that Neptune has changed radically since 1989," says Heidi Hammel of MIT. "New features like this indicate that with Neptune's extraordinary dynamics, the planet can look completely different in just a few weeks."

Astronomers think the spot is actually a window into the lower cloud deck. Like the previous spot, it is surrounded by high-altitude methane ice clouds that appear to have risen high in the atmosphere from below.



NASA/HST

A NEW BLACK EYE in Neptune's atmosphere reflects denser, lower-altitude material in the planet's cloud decks. A series of color images (below) depicts changing Neptunian weather on October 10, 18, and November 2, 1994.



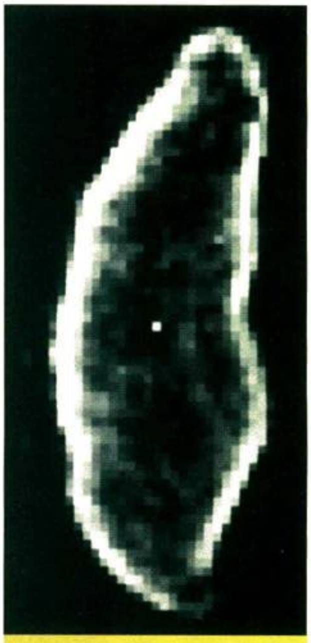
NASA/HST

A Quiet Beast

Radio observations of the Milky Way's core in Sagittarius reveal gas swirling around a 0.5-light-year-diameter region of space at several hundred kilometers per second. Many astronomers think the gas is orbiting a monstrous black hole weighing a million Suns. The gas should heat up and emit torrents of X rays as it makes its final death spiral into the beast. Observations of the galactic core reveal X-ray emission, but much less than such a model predicts.

For this reason, some astronomers have suggested that the beast at the heart of the Galaxy has satiated its appetite, and there is no more gas just outside the black hole left to consume. Other astronomers have suggested that a super-dense star cluster rather than a supermassive black hole inhabits the core. Ramesh Narayan and two colleagues at the Harvard-Smithsonian Center for Astrophysics have proposed an alternative in the April 13, 1995, *Nature*: A gargantuan black hole exists, but it devours 99.9 percent of the energy of the infalling gas, leaving very little energy to zoom away in the form of X rays.

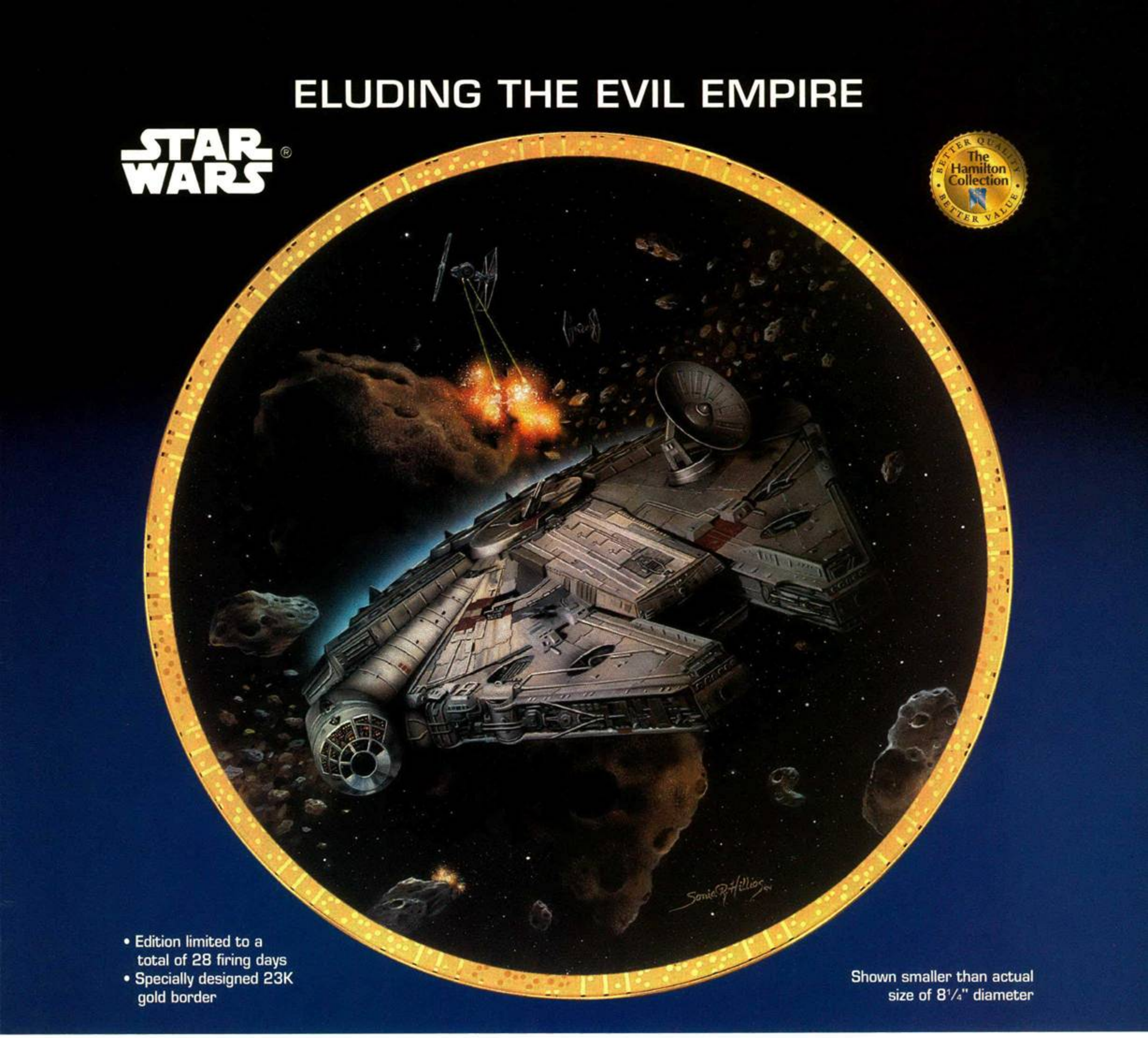
In this model, the gas heats up as it spirals toward its doom. As the gas heats up, it expands and becomes less dense. Because of the low density, the radiation efficiency is very low as well — only 0.1 percent of the gas'



Steven Ostro, NASA/JPL

A CLOSEUP OF 1620 GEOGRAPHOS reveals the asteroid's shape is an oval resembling a sweet potato.

The image, made on August 30, 1994, was created by bouncing radar off the asteroid during its close approach to Earth. Steven Ostro of NASA's Jet Propulsion Laboratory and his group found Geographos is the most elongated object known in the solar system.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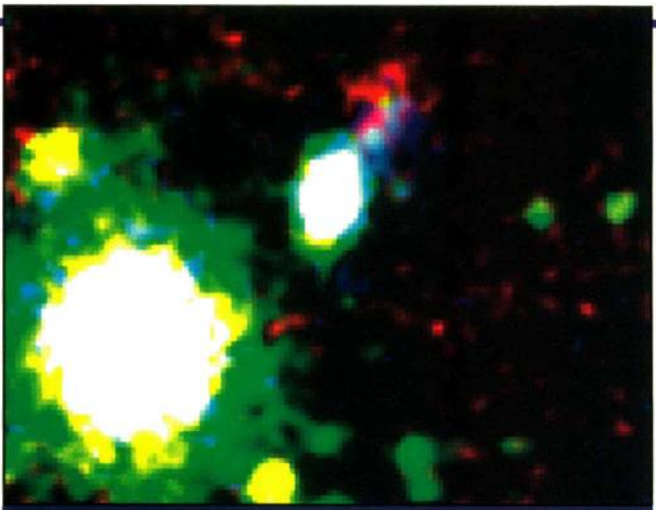
heat energy escapes into space. "This model does a pretty decent job of fitting all of the observations, and it's also consistent with a fairly large rate of mass infall into the black hole," says Narayan.

The model also predicts that a relatively small increase in the amount of infalling gas results in a much larger increase in radiation. This may explain why some galaxies have extraordinarily bright cores.



Arjun Dey, University of California at Berkeley

THE MOST DISTANT GALAXY KNOWN appears as a pinkish oval above and right of center in this image made with the 10-meter Keck telescope on Mauna Kea, Hawaii. The bright, white-green blobs at lower left and center are foreground galaxies much closer to Earth. Known as 8C 1435+63, the most distant galaxy has a redshift of 4.25, which places it 8 to 12 billion light-years away, depending on the assumed value for the Hubble constant.

Missing Mass — Not Really Missing?

Many astronomers are looking for the invisible 90 percent of the universe that can be detected gravitationally but not seen directly — the famous problem of dark matter or missing mass. If two researchers from the University of California San Diego are right, however, what's missing isn't dark matter. They think astronomers haven't yet found most of the universe's normal matter.

"Added together, all the matter in galaxies and gas clouds accounts for only about one-fifth of the luminous matter we estimate exists," says David Tytler of UCSD. "If we're right, then about 86 percent of the ordinary matter in the universe has not yet been found." And that, they feel, should be explored before physicists cook up too many exotic alternative explanations.

Presenting their work at the January meeting of the American Astronomical Society, Tytler and UCSD colleague Xiao-Ming Fan measured the amount of the element deuterium relative to hydrogen in a cool cloud of gas. This gas cloud, which the astronomers believe has never been part of a galaxy and therefore preserves its primordial chemical makeup, lay between a distant quasar and Earth.

The ratio of deuterium to hydrogen they found implies that the universe ought to have a lot more ordinary matter than astronomers know of. "We can't explain where this ordinary mass is," says Tytler, "but we can offer two possibilities. The more exotic one is black holes; all the missing matter could be there. More likely, however, is that all this matter might be in hot, low-density gas clouds we don't yet know of. We're looking for these now."

Another group of astronomers carried out similar measurements on a different gas cloud last year and concluded that the ordinary matter in the universe was about 6 times less than what Tytler and Fan have inferred (see AstroNews, February, 1995). "We're confident we're correct," insists Tytler. "But to be certain we'll just have to get back to the telescope and find more of these clouds."

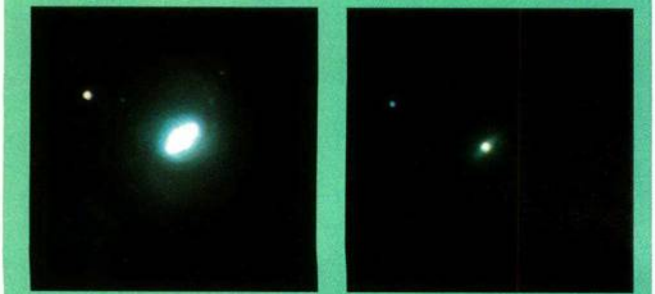
The Sun Eroded Mars' Atmosphere

Over the last 3.5 billion years the Sun blew away Mars' atmosphere. The Red Planet started with an estimated 0.5 to 5 bars of carbon dioxide (1 bar is the pressure of Earth's atmosphere at sea level) and presently has only 0.007 bar. Previously, computer models predicted that a wind of gas and particles from the Sun impacted carbon dioxide molecules and broke them apart, which allowed the equivalent of only 0.14 bar of carbon dioxide to escape into space. New models now show that the solar wind depleted most of Mars' atmosphere.

The new models by David Kass and Yuk Yung of the California Institute of Technology in Pasadena, California, show that much more carbon dioxide is likely to break apart from secondary collisions, permitting the solar wind to remove most of the atmosphere. Mars lost up to 80 meters of water from this process as well, perhaps explaining why Mars is now such a dry planet. The solar wind did not affect Earth the same as it did Mars because Earth's stronger magnetic field shields the atmosphere from the electrically charged particles. Kass and Yung reported their results in the May 5, 1995, issue of *Science*.

TWO VIEWS OF GALAXY M77 suggest it may be a barred spiral rather than an Sb-type spiral as previously thought. The image at left shows a normal-looking inner region of M77, but the right-hand image, with brightness and contrast stretched, reveal the galaxy's inner bar. The bar has been imaged before but never with such clarity.

Astronomy students John C. Barentine and Gil Esquerdo made the images in December 1994 using the 1.3-meter telescope on Kitt Peak, Arizona.



John C. Barentine and Gil Esquerdo, NOAO

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Astronomy Magazine in a recent review said, "The C5 I tested contained superb optics. At high powers, stars exhibited a clearly defined Airy disk surrounded by a bright first diffraction ring and several successively fainter outer rings. This was a telescope that demonstrated how well Schmidt-Cassegrain optics can perform and met **Celestron's** promise of diffraction-limited optics."

In a recent review by *Sky & Telescope*, the following is noted, "the optical correction and factory collimation were excellent. At high magnification, bright stars were surrounded by a classic set of diffraction rings."

The C5 is truly a multipurpose instrument – an astronomical telescope, a spotting scope and a 1250mm f/10 telephoto lens. Great for terrestrial applications such as bird watching, nature study, vistas from view homes or as a superb 1250mm telephoto lens. It even focuses as close as 20'.

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C5$^+$

The C5 with the AC drive system is all that is needed for observational use, especially near AC power sources.

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The electronics of the C5$^+$ have a built-in drive controller with hand control and is powered by a single 9 volt alkaline battery and runs for 50 hours!

The C5$^+$ is the ideal choice for astrophotography. As *Astronomy Magazine* said, "With its combination of fine optics, smooth drive system, and built-in drive corrector, the C5$^+$ proved to be a good telescope for all kinds of astrophotography."

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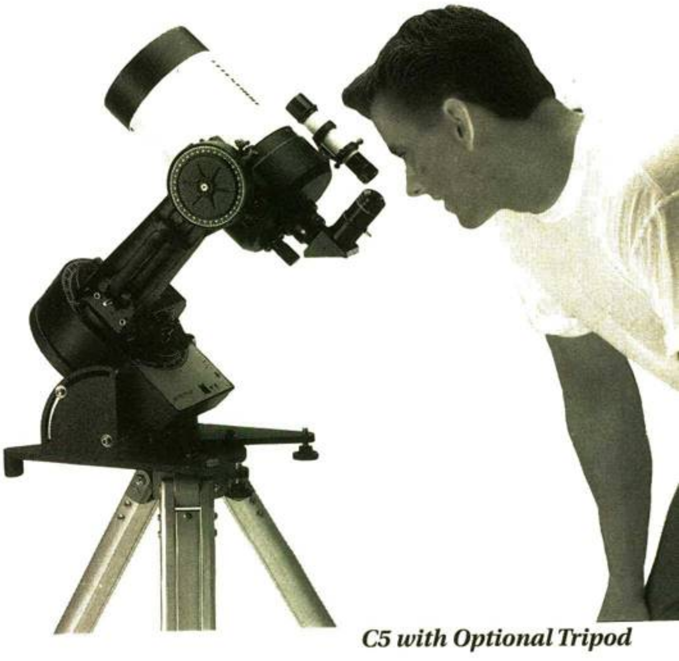

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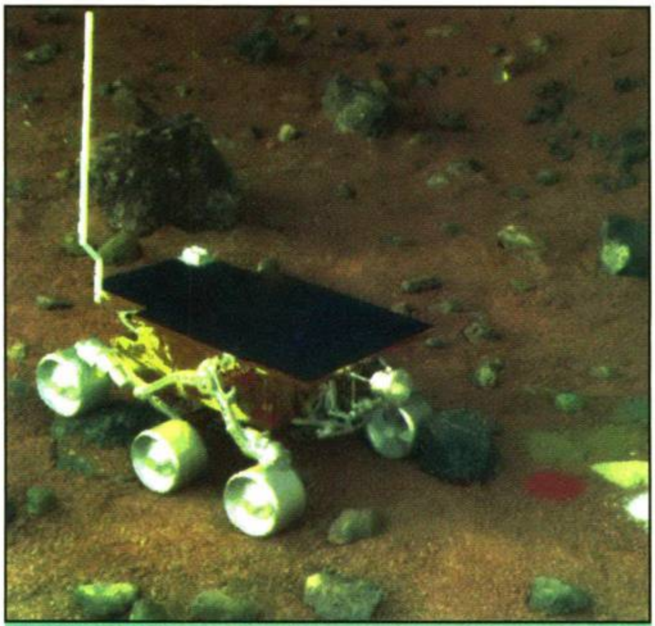
Giant Galactic Halos Detected by HST

Mysterious clouds of hydrogen may actually be vast, gaseous halos surrounding galaxies and not separate clouds inhabiting intergalactic space. The finding suggests that the halos may extend some 20 times farther than the visible edges of the galaxies. If so, they could prove to be a significant reservoir for the dark matter that constitutes 90 percent or more of the universe.

Ken Lanzetta of the State University of New York at Stony Brook and his team examined spectra from six quasars taken by the Hubble Space Telescope in 1991. The spectra showed a complex thicket of absorption lines due to intervening hydrogen gas, much of it within a billion light-years of Earth. (See "A Quasar Lights Up the Universe," September 1991.)

Next the team used several ground-based telescopes to identify galaxies near the clouds and measure their distances. In the majority of cases, the researchers found galaxies lying within about 500,000 light-years of the clouds. The large number of matches convinced them that the hydrogen clouds belong to galactic halos and are not floating free in space.



Peter Smith, University of Arizona

A MOCK-UP MARTIAN ROVER makes its way through the University of Arizona's "Mars garden" during a recent test of the camera planned for Mars Pathfinder. The imager monitored the rover's progress from atop a one-meter mast on Pathfinder's lander during a test last March. Ground controllers planned the rover's route by using images to generate contour plots of the surrounding terrain. The Mars Pathfinder lander/rover combination launches in December 1996 for a July 4, 1997 landing (See "To Boldly Go," December 1994).

Hot Gas Fills a Galactic Donut

A cloud of extremely hot gas is filling the hole in a "donut" of cold gas encircling a distant spiral galaxy. A team of astronomers led by Joel Bregman of the University of Michigan found the hot gas and reported its discovery at the January meeting of the American Astronomical Society.

"With temperatures of 2 million to 13 million kelvins, the gas is so hot that it is invisible to optical telescopes and can be detected only by X-ray telescopes," says Bregman. "This is the first time we've found such hot gas in a spiral galaxy."

The cloud, which has a mass about 300 million times that of the Sun, fills the large central bulge of the spiral galaxy NGC 1291. This galaxy lies about 45 million light-years away in Eridanus. It is a spiral like the Milky Way, but with a much larger central bulge of stars.

"Spiral galaxies like 1291 have disks of stars and cold gas," notes Morton Roberts, a colleague of Bregman's at the National Radio Astronomy Observatory. These disks of cold gas sometimes have mysterious holes in their centers.

"We see the hole in 1291 has been filled with x-ray-emitting gas; the hot and cold gases appear to be mutually exclusive. They don't mix," says Daniel Hogg of NRAO, another member of the team. One consequence of such a hot gas cloud, he notes, is that new stars could not form out of it.

"This result is exciting," says Bregman. "But it's only a single galaxy, and we need to observe others to determine if the phenomenon is general."

Don't Blame the Sun

The Sun may have less to do with climate changes today than it did three-quarters of a century ago. David Thomson of the AT&T Bell Labs in Murray Hill, New Jersey, says in an April 7, 1995, article in *Science* that changes in average annual temperature since 1922 do not follow the annual cycle of seasons and thus rule out solar variability as a cause. The most likely culprit is carbon dioxide gas. Earth's atmosphere warms when the gas traps the heat of solar energy that has been absorbed and then reradiated in the infrared by Earth's surface. Many scientists thought this greenhouse effect was controversial and expected the Sun to play a more significant role in recent changes in the climate.

Thomson reports that the Sun probably did cause some climate changes between 1854 and 1922, but since then greenhouse gases have dominated. Previous studies tracked seasonal temperatures from equinox to equinox, the so-called tropical year. In fact, Thomson claims that researchers should use the year measured from Earth's closest approach to the Sun to the next closest approach. This includes the effects of precession (the wobble of Earth on its spin axis) when determining the amount of sunlight received. Using the tropical year masks subtle changes in the annual average temperatures.

Remnants of Tunguska

An experimental approach by a team of Italian physicists has uncovered new information on the nature of the celebrated Tunguska incident of 1908. (See "Death from the Sky" by Christopher Chyba, December 1993.) On June 30 of that year an explosion flattened more than 2,100 square kilometers of forest along the Podkamennaja Tunguska River in central Siberia. Scientific expeditions cataloging the destruction,

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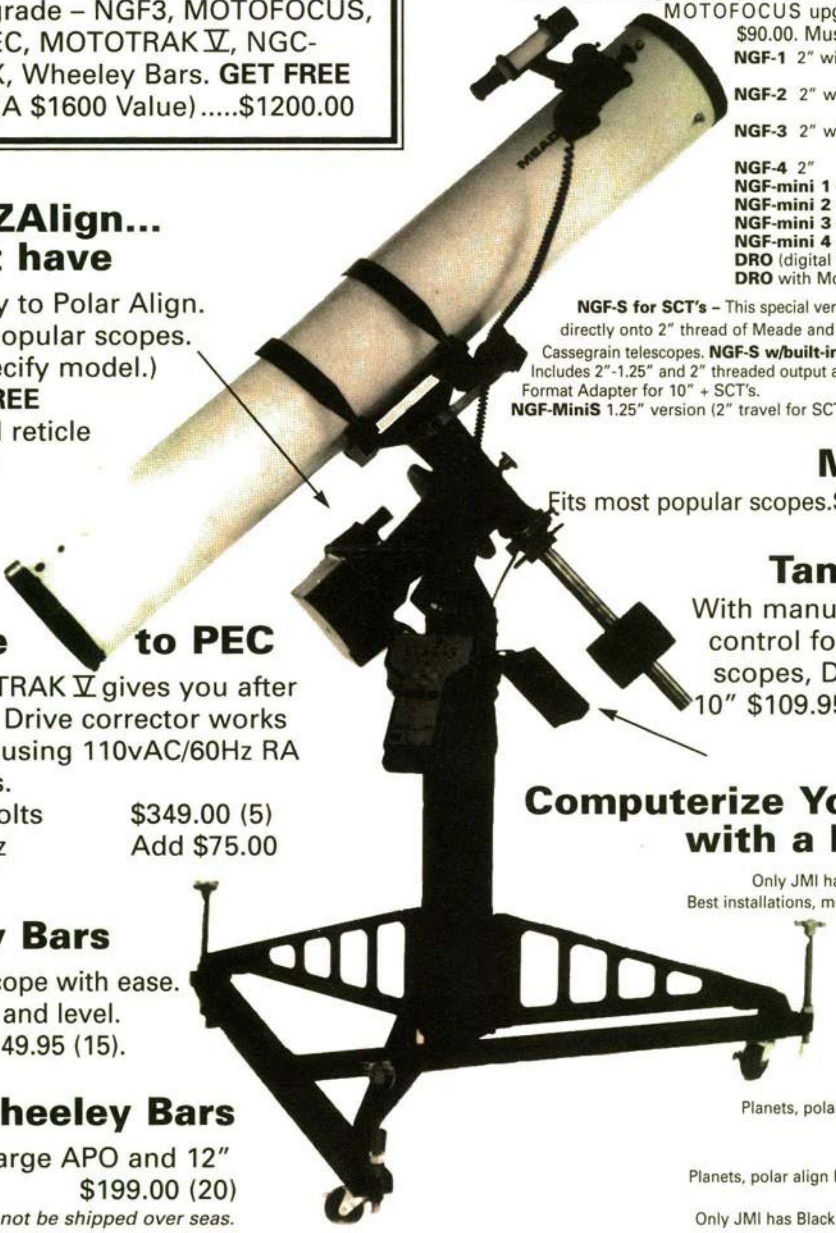

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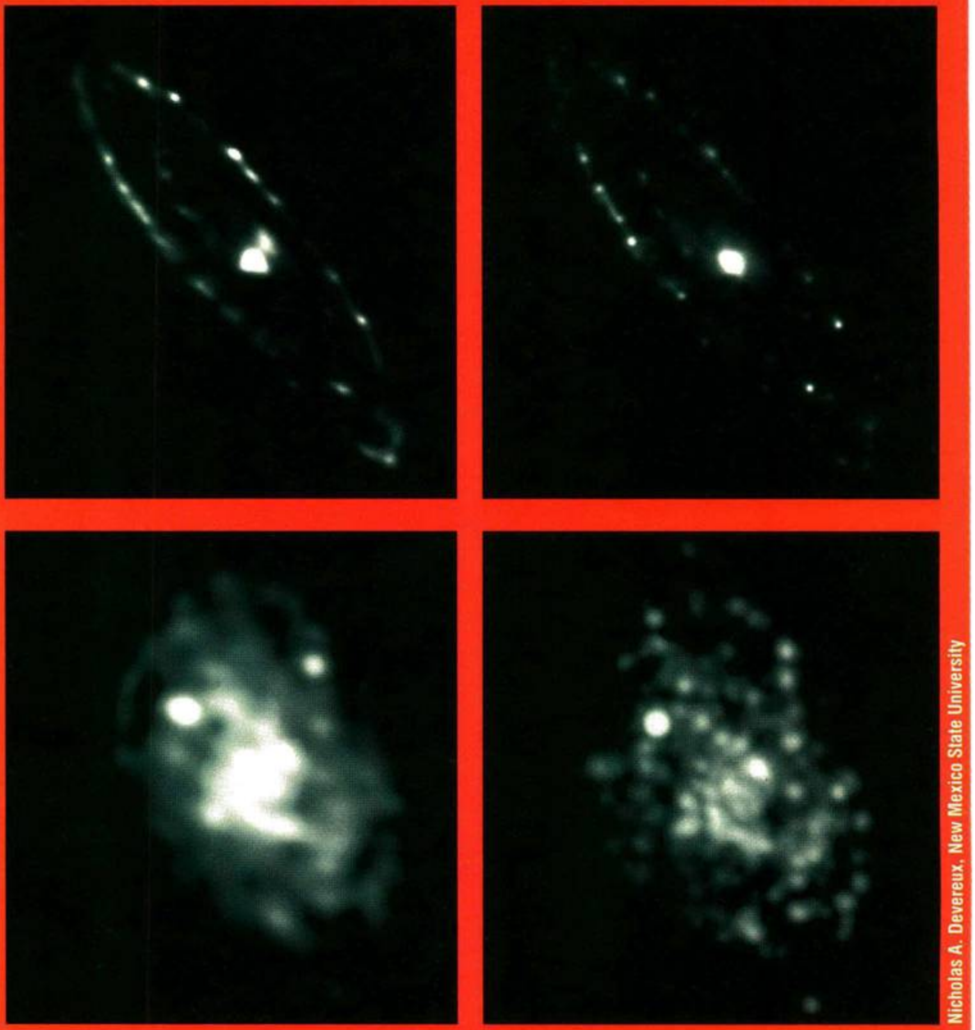
analysis of the debris, and computer modeling of asteroid and comet impacts have for the past 60 years pointed toward the explosion of a tiny asteroid or comet nucleus over the region. The problem with being certain of the scenario was that nothing was left of the impacting body itself.

Now G. Longo of the Università di Bologna and his colleagues have examined fluid resin in the conifers around the site, expecting that extraterrestrial particles from the impacting body may have been trapped in the resin and subsequently hardened, like ancient insects in amber.

Longo and associates used a scanning electron microscope to examine 7,163 particles recovered from the site and from two control sites. They found anomalously high abundances of elements such as iron, calcium, aluminum, copper, gold, zinc, and oxygen in the Tunguska site samples, strongly peaking around 1908. The elements found were, in the opinion of the scientists, pieces of the Tunguska impacting body. Subsequent analysis, published in *Planetary Space Science* (1994), suggests the Tunguska body was a normal density stony meteorite that exploded above ground and scattered its debris over a wide area as well as damaging the ground below.

Looking Inside M31 and M33



Nicholas A. Devereux, New Mexico State University

WARM DUST AND YOUNG, HOT STARS correspond beautifully in these images of the Andromeda Galaxy (top) and M33 in Triangulum (bottom). In each case, the left-hand picture shows far-infrared and the right-hand image hydrogen-alpha light. The infrared light comes from warm dust and the hydrogen-alpha from hot stars exciting gas clouds. The striking similarity of the views means the hot stars warming the dust must also be energizing the gas.

Where the Hot Stars Are

Astronomers have long debated the kinds of stars that cause dust to glow warmly across the disks of galaxies. New images of the Pinwheel Galaxy (M33) in Triangulum and the Andromeda Galaxy (M31), made with the Burrell Schmidt telescope at Kitt Peak National Observatory in Arizona, appear to have resolved the issue. Research based on the images shows young, massive stars heating dust causes the far-infrared emission. The work was carried out by a team headed by Nicholas A. Devereux of New Mexico State University.

The images, which show M31 and M33 in hydrogen-alpha light, depict energy from the galaxies' gas clouds, which are excited into glowing by the hot, young stars. When coupled with earlier, far-infrared pictures of the galaxies made by the Infrared Astronomical Satellite, the pictures reveal a striking similarity. That the far infrared and hydrogen-alpha emission in the galaxies correspond so well suggests that the same massive stars that heat the gas clouds also warm the dust.

The hydrogen-alpha images, then, can be used to trace the distribution of massive stars in the galaxies, those in the range of 16 to 40 solar masses. These stars are

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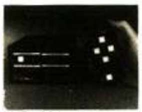

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arranged in a ring and near the nucleus of the Andromeda Galaxy and are scattered throughout the disk of M33.

The massive stars are young, and consequently reveal where stars are forming in the galaxies. The result is important: Hydrogen-alpha images exist for only about 200 galaxies, but IRAS images, which astronomers now know can tell them where stars are forming, exist for thousands of galaxies.

An X-ray Jet in the Vela Pulsar

Astronomers working with the ROSAT X-ray satellite have discovered a jet of high-energy X rays streaming from the Vela pulsar. The finding may help explain how pulsars lose energy, an observational fact that theorists have had difficulty explaining.

Craig Markwardt and Hakki Ögelman of the University of Wisconsin in Madison reported on their observations of the jet in the May 4, 1995, issue of *Nature*. The jet originates within the Vela pulsar, a rapidly rotating neutron star that exploded as a supernova some 10,000 years ago. The pulsar spins 11 times each second but like other pulsars is gradually slowing down. Astronomers have long debated how this rotational energy is lost. Radiation, the way the Sun and most other stars lose energy, accounts for less than 1 percent of the energy loss.

The newly discovered jet could be the answer. The jet, which measures about 20 light-years long and 5 light-years wide, speeds along at roughly 1,100 kilometers per second. The power needed to drive the jet works out to just about the rate at which the pulsar is losing its rotational energy.

AMATEUR NEWS

Astrophotography Goes Public

Sharing the wonders of astrophotography took center stage at AstroImage '95, held March 11 on the Fullerton campus of California State University. The one-day conference drew over 120 enthusiasts and was hosted by the university's physics department and the Orange County Astronomers. Talks covered a wide variety of topics, from remotely operated telescopes with CCD cameras to the latest in film emulsions for astronomical photography.

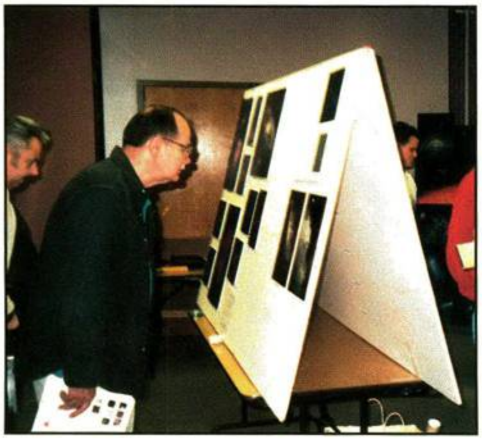
Even though CCDs seem to be the rage today, Brad Wallis, an astrophotographer from the old school with more than 20 years of experience, was quick to admonish that "film ain't dead yet!" With partner Bob Provin, he uses 4x5-inch film mounted in custom film holders on a 6-inch apo-refractor. The team's results look strikingly similar to pictures taken with the 48-inch Schmidt telescope on Palomar Mountain during the 1950s.

To add a dimension of movement to astrophotography, Seattle imager Alan Macfarlane created a video made from still photos he took of Mars. The tape reveals changing Martian cloud and polar cap detail during the last apparition. Macfarlane stresses that television is an ideal medium to convey to the public the wonders of the sky.

Concerning another public education effort, Gil Clark of the Telescopes In Education program reported on his use of the 24-inch telescope on Mt. Wilson, California. Schools and amateurs anywhere in the world now have greater ease in accessing the scope and its CCD imaging system by modem. Nearly 100 schools have tapped the program to date, and negotiations are now underway with the Mount Wilson Institute for part-time use of the mountain's 60-inch reflector.

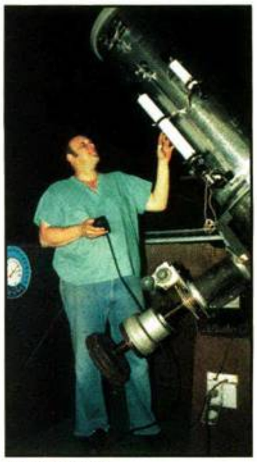
Even the Sun seems to be going public. Oakland-area solar photographer Mike Rushford explained how he built an automated solar observatory to take daily pictures of the Sun. The hydrogen-alpha images are on his "Eyes on the Skies" computer bulletin board, accessible by dialing (510) 443-6146.

Astrophotographers interested in obtaining information about next year's AstroImage can write the Orange County Astronomers at 2195 Raleigh Ave., Costa Mesa, CA 92627.
— *John Sanford*


John Sanford

SKYSHOOTERS SWAP SHOP TALK and eye each other's imaging handiwork during a break between speakers. Among other things, this year's AstroImage conference looked at popularizing astronomy through photography.

Astrophotographer Is Honored


Donald Parker

During its annual science meeting at the University of Maryland last June, the Astronomical Society of the Pacific awarded its Amateur Achievement Award to planetary astrophotographer Donald Parker.

"This award was established to recognize significant contributions to astronomy," said ASP Secretary John Gaustad. "We wish to recognize Parker's outstanding achievements in planetary imaging."

Parker, a retired anesthesiologist who lives in Miami, Florida, started photographing the planets more than 20 years ago. He is pivotal in an ongoing effort by the Association of Lunar and Planetary Observers to monitor Mars. He works from a balcony observatory that houses a 16-inch f/6 reflecting telescope (see "Seeing and Believing," September 1994).

Besides receiving a $250 prize, Parker joins other amateur astronomers recognized by the Society over the past 20 years, including deep-sky astrophotographer Jack Newton, lunar and planetary observer Walter Haas, and David Levy of Comet Shoemaker-Levy 9 fame.

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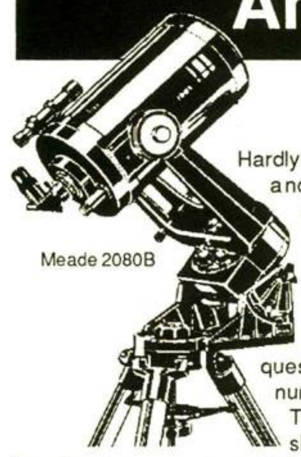

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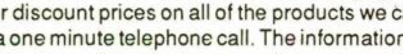

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We supply DayStar University H-Alpha solar prominence filters to colleges and universities for their treasured Alvan Clark refractors; DayStar ATM filters to high schools for their 8" Schmidt-Cassegrains; DayStar ATM and T-Scanner filters to individuals for their SCTs and the ultra-premium Questar 3.5" Maksutov-Cassegrains that we also sell. And we can supply *you* with a DayStar H-Alpha filter for your refractor, Maksutov, or Schmidt-Cassegrain – at a price that saves you money.

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May Meetings Kick Off Observing Season

Clear, dark skies, large backyard telescopes, and observational talks were the dominant themes at this year's two large, springtime gatherings of amateur astronomers. Some 710 people flocked to the Prude Ranch in Fort Davis, Texas, for the 1995 Texas Star Party, held May 20-28. Though a few violent thunderstorms rolled through the area, which stands in the shadow of McDonald Observatory in the Davis Mountains of West Texas, most of the week featured transparent skies and steady seeing, so that by midweek most attendees were exhausted from staying up all night every night. A record number of large telescopes stood across the observing fields on the ranch, and dozens of deep-sky aficionados caught a glimpse or two through a 36-inch scope before the week expired. Others contented themselves with CCD imaging, as evidenced by the faint glow of computer screens scattered through the forest of scopes.

ASTRONOMY: John Shibley

TELESCOPE JUNKIES scope out each other's creations of formed composites and low-expansion glass. At right is a 16-inch binocular telescope that wowed observers at night. The green, open-truss scope on the left is a commercial telescope.

When not observing, TSP-goers caught a *stellar lineup* of talks from amateurs and a few professional astronomers. Larry Mitchell of the Houston Astronomical Society, owner of a 36-inch portable scope, reported his observations of Abell galaxy clusters. Finnish amateur Riku Henriksson described backyard observing in his home country, emphasizing his impressively detailed eyepiece drawings of clusters and nebulae. Groups from England, Belgium, and Peru also participated in the lectures by amateur astronomers.

Astronomy popularizer Timothy Ferris of the University of California at Berkeley pushed the limits of inquiry in his talk "Is the Big Bang Dead?" After exploring various aspects of the Big Bang controversies, the Hubble constant, galaxy formation in the early universe, quasar evolution, and the like, he concluded that it probably isn't vanquished, even if some unexplained details make for fun controversies.

Professional astronomers provided a detailed look at various aspects of galaxy evolution and cosmology. Robert Williams, director of the Space Telescope Science Institute in Baltimore, outlined the latest results from Hubble and what it may accomplish in the near future. The many recent developments in galaxy evolution, big bang theory, and distance scale and age of the universe, astounded the audience. The Institute is planning to abolish the amateur observation program with Hubble due to its high cost in staff time and small participation.

The most anticipated talk, however, came from Halton Arp of the Max-Planck-Institut für Astrophysik in Munich. Long known as an unconventional thinker on the subject of redshifts as distance indicators in the universe, Arp outlined fresh X-ray observations of quasars surrounding a number of nearby galaxies. His interpretation of the X-ray isophotes suggests a physical connection between the quasars and galaxies despite their radically different redshifts. If Arp is correct, then one of the cornerstones of measuring and therefore understanding the universe is in big trouble. Although many in the audience did not seem eager to abandon conventional astronomy, they enjoyed observing Arp galaxies — those discovered and cataloged by Arp — with Arp himself, long into the darkness under the star-splashed Texas sky.

ASTRONOMY: David J. Eicher

ASTRONOMICAL ICONOCLAST, Halton Arp describes his belief that quasars are nearby objects ejected from the centers of normal galaxies. He lectured the audience at the 1995 Texas Star Party in Fort Davis, held last May.

Far from the ranch, in the sunny mountains of Southern California, one can almost touch the heavens, or at least observe and capture them on a CCD chip. That's what over 1,800 amateur telescope makers, skyshooters, and other astronomy enthusiasts from all over the country did during the 27th Riverside Telescope Maker's Conference, held last Memorial Day weekend in the San Bernardino Mountains overlooking Los Angeles. Besides drawing a healthy number of telescope makers who showed off their latest creations, the conference also attracted its share of deep-sky observers and imagers.

A variety of large-aperture telescopes, some with mirrors as large as 30 inches across, took advantage of the clear mountain air to give observers stunning views of springtime galaxies and, later in the night, nebulae and star clusters scattered along the summer Milky Way.

On the electronic side, conference organizers sponsored a "CCD camera shootout" that drew about a dozen commercial camera manufacturers. Each vendor shot from a list of seven targets during the three-day weekend. The shoot-out let prospective buyers compare how well the cameras performed in the field and gauge for themselves image quality. Targets included bright Jupiter as well as notable deep-sky objects like the galaxy M82 in Ursa Major, plus a faint galaxy in Draco, NGC 4512, which sported a newly discovered supernova.

During the daylight hours, RTMC's legendary swap meet saw everything from new telescopes to meteorites change hands. Tables and booths lined no less than three 100-yard paths. The bazaar ran concurrently with talks held in the dining hall, the majority of which dealt with all aspects of the up-and-coming technology of CCD cameras.

For information on the 1996 Memorial Day Weekend gathering, write RTMC '96, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730. □

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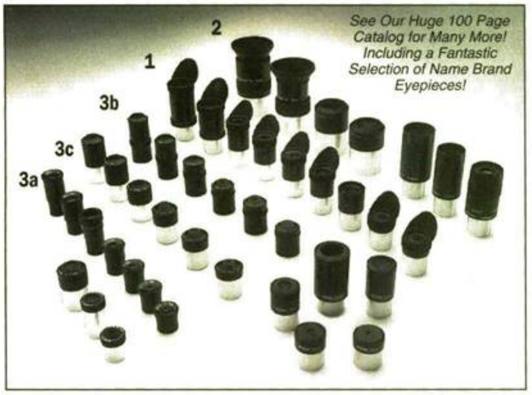

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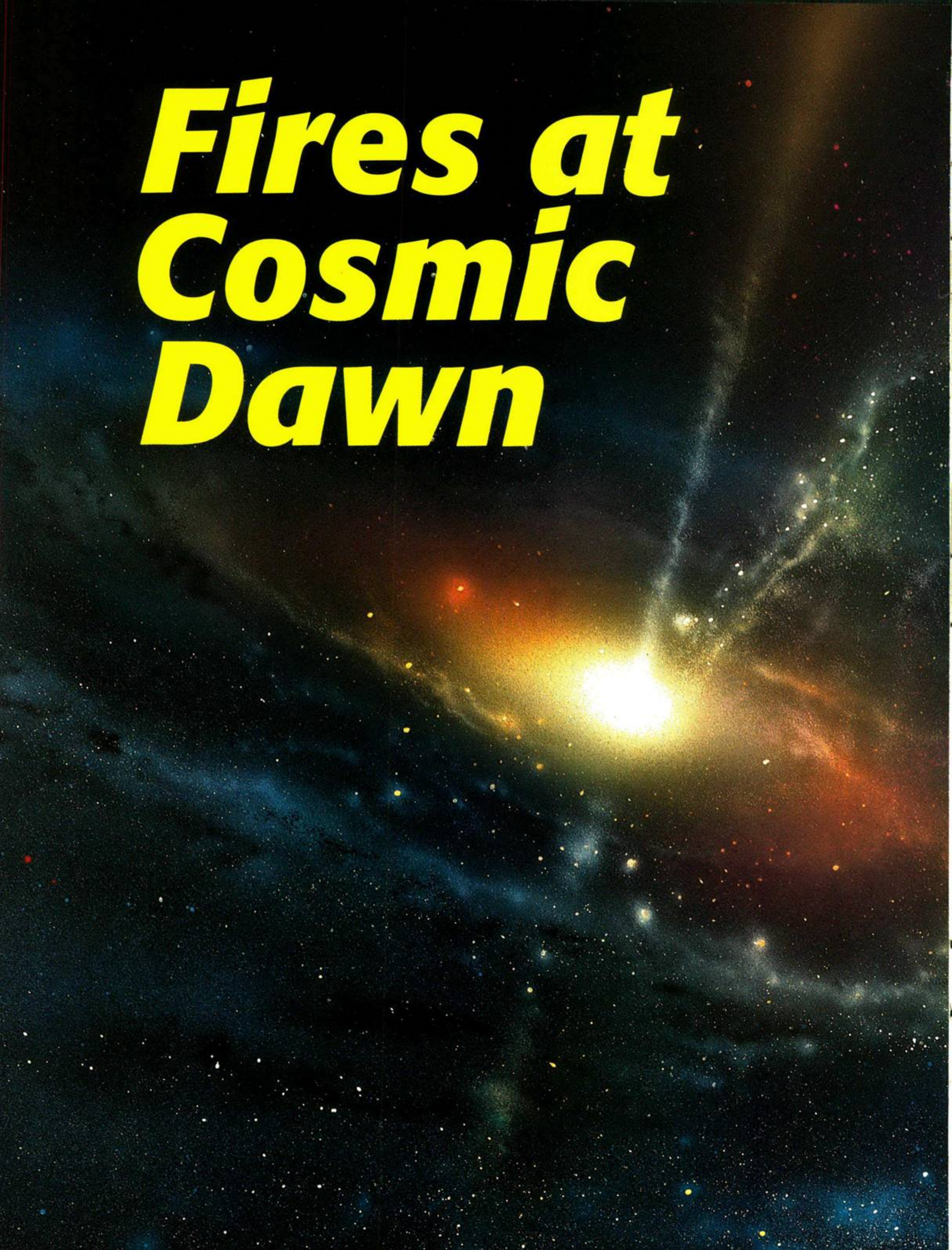


Robert Eggleton

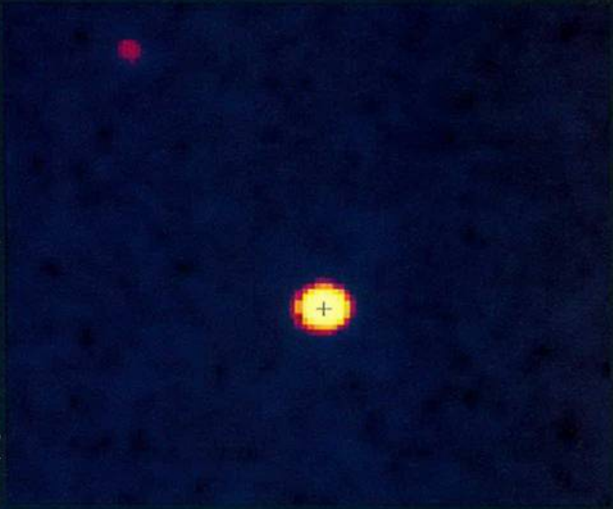
Quasars — extremely distant energetic beacons — are providing astronomers with clues about the births of galaxies in the early history of the universe.

by S. George Djorgovski

Because galaxies are the basic building blocks of the universe, astronomers would love to know how they came about. Yet when they look out into space and back in time, the only things astronomers have seen so far in the depths of the universe are quasars or quasarlike objects — no normal, young galaxies. This conspicuous absence of protogalaxies from which the present-day galaxies have evolved represents a major mystery. Quasars, by the way, are extremely energetic outbursts that occur in the centers of some galaxies. They can outshine an entire host galaxy, although the activity of whatever powers the quasar is confined to a region very close to the galaxy's nucleus.

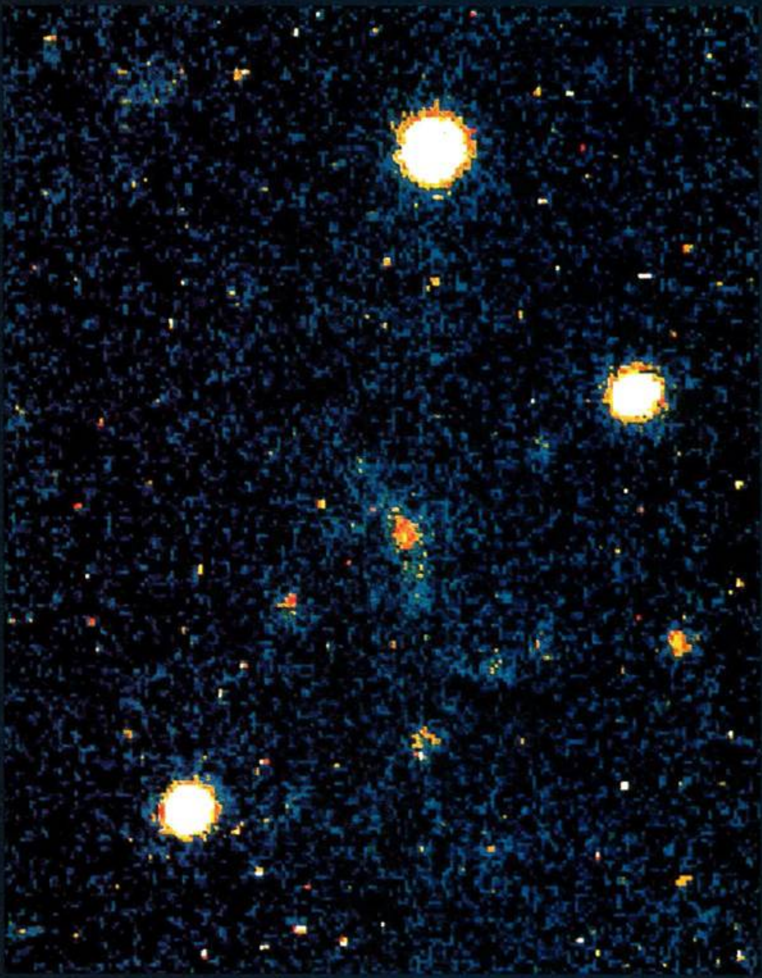
The origins of quasars are as mysterious as those of galaxies. Most astronomers now believe that the spectacular, high-energy emissions quasars produce result from giant black holes in their centers. How and when quasars formed, and how massive black holes power quasars, remains unclear.

Indeed, two key questions of modern extragalactic



S.G. Djorgovski, Palomar Observatory

THE MOST DISTANT OBJECT KNOWN, a quasar designated PC 1247+3406, lies about 90 percent of the way back to the Big Bang. Its redshift of 4.9 suggests a distance of approximately 13½ billion light-years.



THE RADIO GALAXY 4C 41.17 (center) is one of the most distant galaxies known. It has a redshift of 3.8, which may translate into a distance of about 12½ billion light-years. The galaxy's clumpy appearance may reveal a merging and still-forming system.

B.T. Soifer et. al, W.M. Keck Observatory

astronomy are the origin and evolution of galaxies, and the origin of quasars and other active galactic nuclei, especially the earliest ones.

A growing body of evidence indicates that these two problems may be fundamentally related — that the formation of galaxies and their active nuclei occurred nearly at the same time. The basic idea is not new: It is tempting to associate the most distant quasars with young galaxies, and speculations to this effect have been around practically since the discovery of quasars some 30 years ago. Intriguing new developments, however, in both theoretical modeling and in observations of the distant universe support the idea that young galaxies and the first quasars are deeply connected.

How Did Galaxies Form?

The universe is the realm of galaxies, about a hundred billion of them, each containing about a hundred billion stars. However, on a large scale, galaxies are to the universe what cells are to a human body. The origins and evolution of galaxies are among the key problems of astronomy and cosmology today. It is thus of great interest to find out how they formed in the early universe.

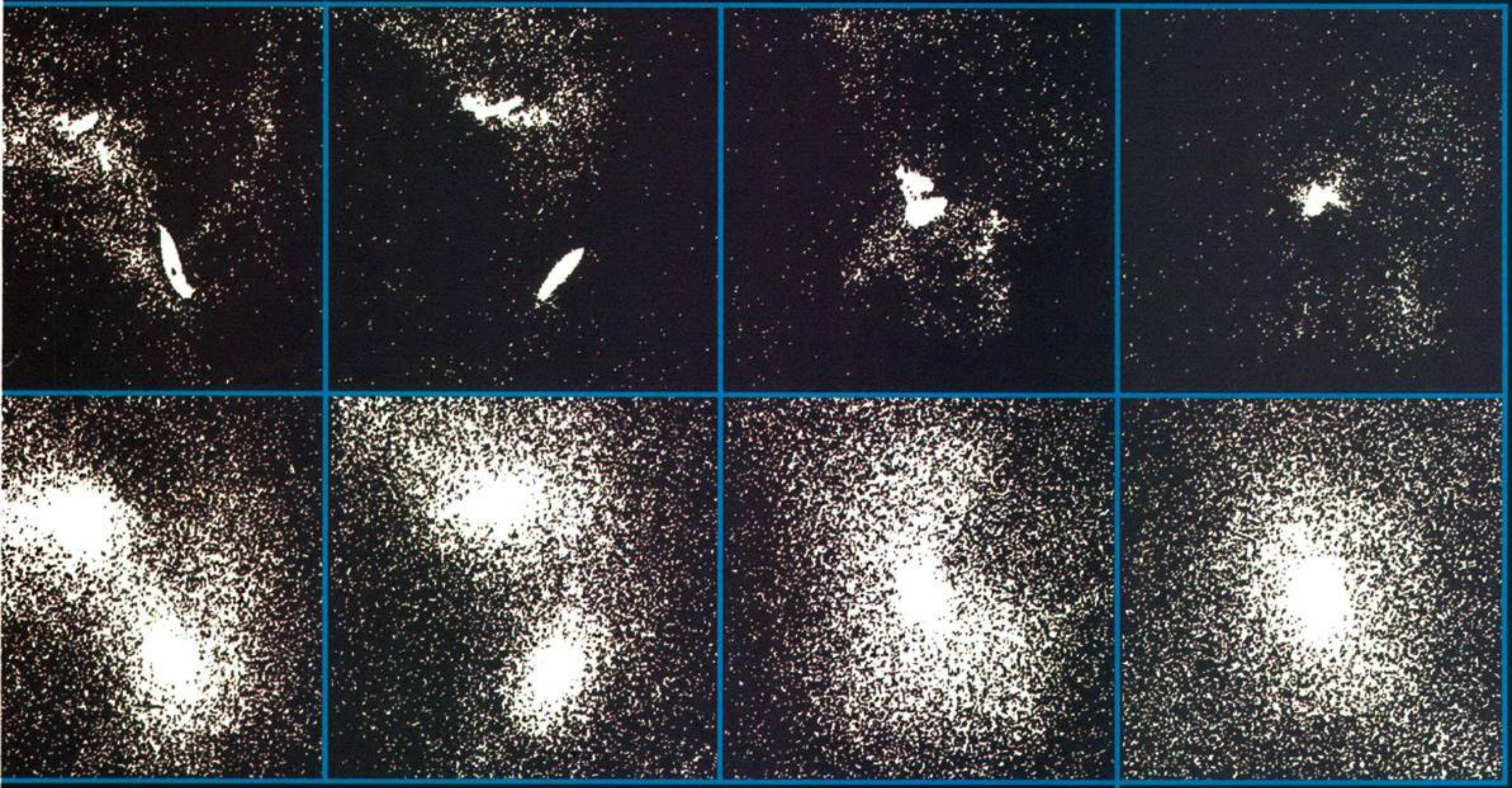
The quest for protogalaxies has been going on for a number of years now. Astronomers are looking for progenitors of normal galaxies at large redshifts, young galaxies undergoing their first major bursts of star formation, which would evolve into normal galaxies today. Redshift is a measure of distance on cosmological scales. Because wavelengths of photons expand with the expanding universe, the longer a photon travels toward us, the longer and redder its wavelength becomes. Astronomers use this relationship as a gauge of distances to very remote objects. Astronomers can also use redshifts as a shorthand for a period in the universe's history. Higher redshifts indicate earlier epochs.

What comes out of the Big Bang is a universe filled with a gas consisting of approximately 75 percent hydrogen and 25 percent helium, plus a large amount of so-called dark matter, whose composition is as yet unknown. Slight "lumps" in this primordial mixture of gas and dark matter somehow evolve into the large-scale structure and galaxies made of stars and gas that we see today. Mapping this process from its inception until the present era is the central task of modern cosmology.

The initial stages of the process are reasonably well understood, at least in principle. The lumps in the early universe naturally grow under their own self-gravity. The primordial material falls toward the densest spots, thus adding to their mass.

On large scales of clusters and superclusters of spinning galaxies, this process continues even today. The puzzle starts once we consider what happens on the scales of galaxies, or smaller, where the primordial gas out of the Big Bang somehow makes stars. There, theories fail, and the numerical models are not quite good enough yet. Understanding galaxy formation is still an empirical question to be answered by observations.

Disks of normal spiral galaxies like our own probably


J. Barnes, University of Hawaii

GALAXIES MERGE in a computer simulation produced by astronomers Joshua Barnes and Lars Hernquist. The top panels show the behavior of gas, and the bottom panels the behavior of stars in the final stages of a merger of two gas-rich galaxies. This would result in a major starburst and could lead to an active nucleus or a quasar.

form gradually, at a nearly uniform pace through the history of the universe. On the other hand, spheroidal or bulge components of galaxies, including both spirals and ellipticals, are believed to have formed in massive, relatively short bursts of star formation, mostly early on in the history of the universe. This may have happened not long after the Big Bang.

Another important event happened early in the universe's history, the appearance of quasars and powerful radio galaxies. Astronomers now generally believe that these objects are powered by gas falling into supermassive black holes that reside in their centers, a process that can release a lot of potential energy. By definition, and as their name implies, black holes do not shine by themselves. Rather, the gas falling toward a black hole heats up, and from a complicated mixture of incandescent gas, plasma, and magnetic fields, the great luminosity of quasars emerges. Although astronomers have some understanding of these processes, how the black holes get there, and how they are supplied with enough gas for this activity is much less clear.

We know that some structure on the scales of galaxies and smaller must have formed quickly, since we see quasars and radio galaxies 80 to 90 percent of the way back to the Big Bang. However, quasars and other active objects are peculiar (even though they may reside inside otherwise perfectly ordinary galaxies, which they can outshine greatly), and their high energy output is not telling us directly about the way stars form in the earliest protogalaxies.

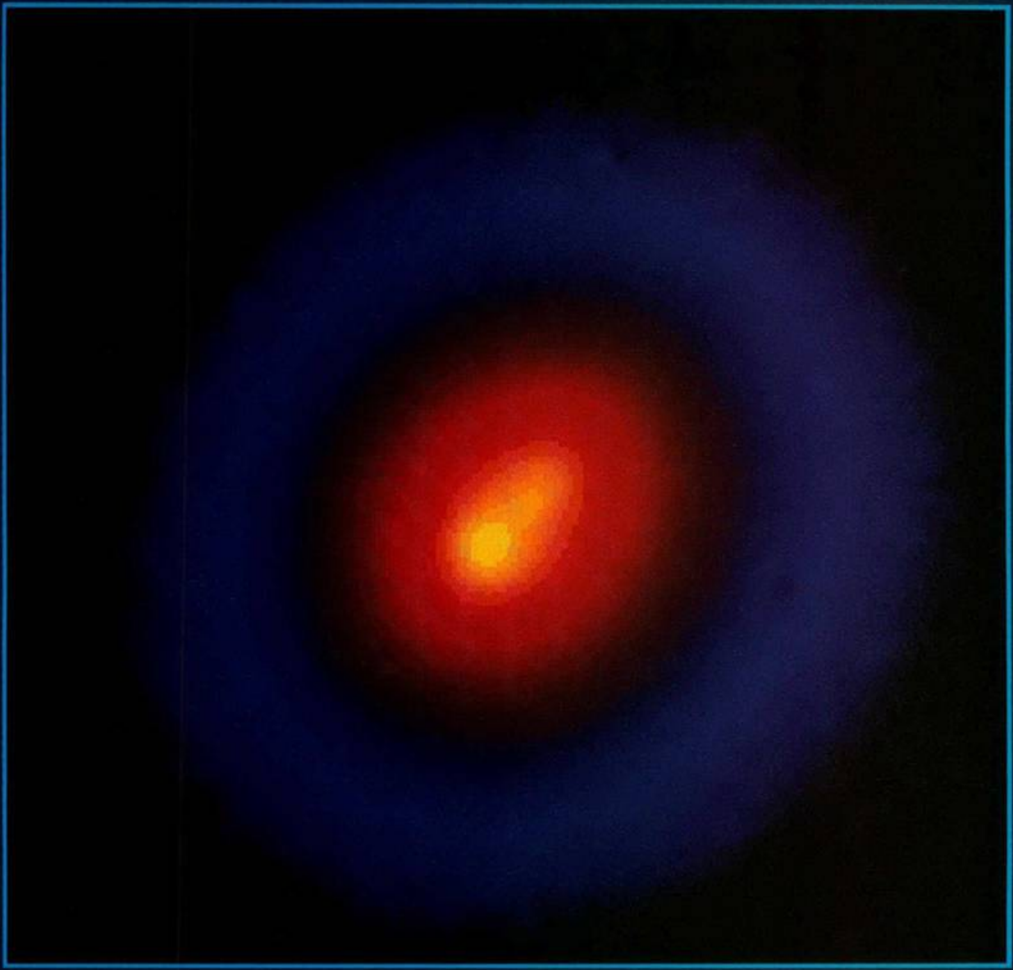
Quasars and Their Origins

Most astronomers believe that quasars are the active nuclei of galaxies, although not every galaxy nucleus contains an active quasar at any given time. In the local universe now, about one galaxy in 10 million harbors an active quasar, but there are many more galaxies with similar, less luminous active nuclei. When quasars were at their peak, at redshifts of 2 or 3, they were at least a thousand times more numerous than they are today.

Quasar episodes probably do not last long compared to a galaxy's total lifetime. It's possible that most or all massive galaxies have undergone at least a brief quasar phase at some point in their past. Astronomers now think that a typical active quasar episode may last some tens of millions of years, less than one percent of a galaxy's age. It's even possible that such episodes of quasar activity may repeat.

Thanks to their great luminosity, quasars are the most distant objects known, and it would be good to put them to some use as probes of galaxy formation. They appear on the scene early, at redshifts higher than 4, when the universe was only one or two billion years old. The most distant quasars known approach a redshift of 5, but it's likely that some are even more distant. Quasars peak in number between redshifts of 2 and 3, and then their frequency declines significantly at great distances. In the history of the universe, quasars begin forming abruptly, explode a thousandfold in numbers, and then trail off to the present day.

MASSIVE BLACK HOLES may inhabit the centers of galaxies today. This false-color image of the nucleus of the Andromeda Galaxy, made with the Hubble Space Telescope, shows a double structure possibly caused by a merger long ago. Earlier studies suggested stars may be moving rapidly about the galaxy's center, a good indication of a large, invisible mass like a black hole.



I.R. King, University of California, Berkeley

If all quasars reside in galaxies, their appearance may be telling us something about the appearance of galaxies themselves. Their apparent disappearance, on the other hand, may be telling us about changes in their fueling processes, since the galaxies are still here, even though most quasars are now extinct.

The Fiery Births of Galaxies

The two main processes in making a galaxy involve assembling material into galaxy-size clumps, and converting primordial gas into stars. The first process is probably dominated by dark matter, which accounts for about 90 percent of the total mass of galaxies, but it is by definition difficult to detect. This process can be studied theoretically, using numerical simulations of the formation and growth of structure in the universe.

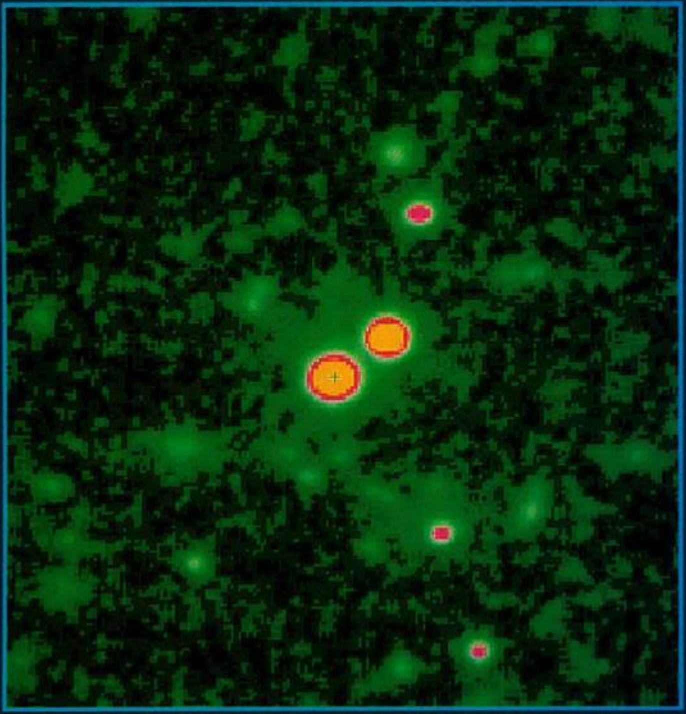
Star formation in young galaxies can be observed directly, at least in principle, since young stellar populations are prodigiously energetic. Stars generate light, and at the same time they create heavy elements, whose abundance can be measured in the galaxies we see today. Astronomers estimate that approximately 5 percent of the initial mass of primordial hydrogen was *burned into* helium and heavier elements in the thermonuclear furnaces of the first stars. These ashes of burned-out starbursts of yore are a fossil evidence of the epoch of galaxy formation. It is difficult, however, to reconstruct a full-blown fire just by looking at its ashes.

Forming stars in protogalaxies can be a very energetic process. For an average elliptical galaxy, the resulting energy from the early star formation adds up to about 10^{61} ergs (a 10 followed by 60 zeros, or about 10 "gadzillions"). This energy may be released over a period of a hundred million to a billion years. This corresponds to about a trillion times the luminosity of our Sun. To try to visualize this, a one-megaton nuclear warhead generates about 4×10^{22} ergs, and an all-out global thermonuclear war would generate about 10^{26} ergs. The formation of an elliptical galaxy can then be compared to ten billion billion global thermonuclear wars per second going on continuously for a few hundred million years. This is a lot of energy — enough so that we can hope to see it clear across the observable universe.

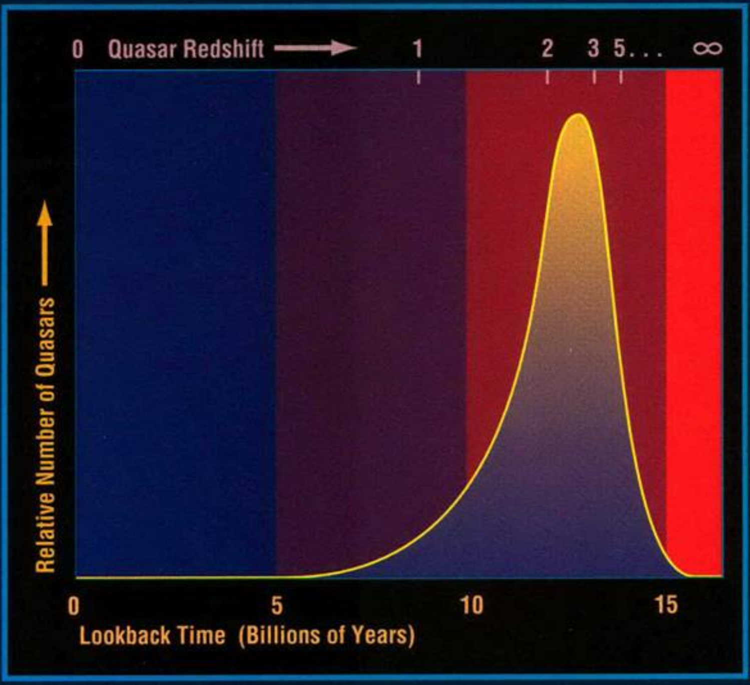
The luminosities and total energies released by average quasars are of the same order of magnitude, or even greater. This may or may not be a coincidence. Astronomers believe that quasars derive their energy not from the nuclear burning in stars, but from an entirely different mechanism, accretion of matter onto a supermassive black hole. The fact that the energy produced by the two processes is so similar hints at a possible fundamental connection between the formation of galaxies and the origin of quasars. (Some authors have even proposed that quasars are nothing but ultraluminous starbursts, with no massive black holes at all; that is still very much a minority viewpoint.)

But the similarity in brightness between young starburst galaxies and quasars poses another problem. If galaxies are that bright, then astronomers should be detecting them early in the universe's history with today's

THE BINARY QUASAR PKS 1145-071 consists of a pair of quasars some 9 billion light-years away. The two may have formed when an interacting pair of galaxies triggered quasars in their centers. The pair lies inside a rich galaxy cluster, which implies that quasars may be used as beacons to such objects.



S.G. Djorgovski, W.M. Keck Observatory



S.G. Djorgovski, after Maarten Schmidt, Don Schneider, and James Gunn

THE RISE AND FALL OF THE QUASARS. The curve, based on deep quasar surveys, indicates the change in numbers of quasars over time. Our time is at bottom left, and proceeds backwards toward the Big Bang at bottom right. Notice the rise in the number of quasars 12 billion years or so ago, which may have followed the appearance of the first galaxies.

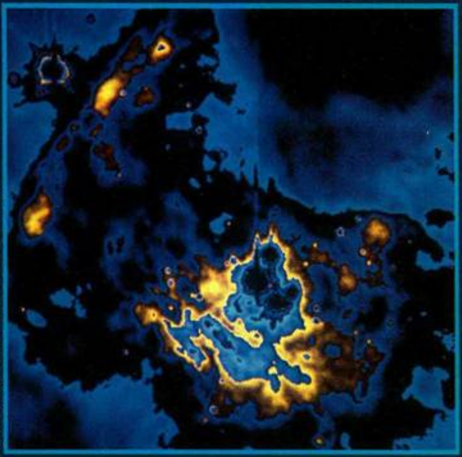
generation of 3- to 10-meter telescopes. Yet despite many searches for young galaxies without active nuclei, no such population has ever been seen. They should be both bright enough to be detected by our existing telescopes and detectors, and numerous enough to be seen in the volume surveyed so far. The reasons for this conspicuous absence of protogalaxies remain unclear.

It's possible that many or all young galaxies were obscured by interstellar dust, which would absorb the ultraviolet and visible light from their young stars, and reradiate it in the far-infrared, out of the range of optical and near-infrared telescopes. This process could effectively hide protogalaxies from view. However, energy doesn't just disappear, and even if it is absorbed by dust, it should emerge somewhere else. This would leave an observable imprint, in the form of excess radiation in the spectrum of the cosmic microwave background. Extremely precise measurements of the cosmic microwave background spectrum by the Cosmic Background Explorer (COBE) satellite place strong limits on how much of the protogalactic light could have been hidden in this way. The measured spectrum of the microwave background matches that expected from the universe. If there were dusty protogalaxies shining in the far-infrared, that energy would have been detected easily as an excess signal above the expected level, and nothing like that has been seen by COBE. Besides, the first stars must have formed in a dust-free environment, because dust grains are composed of heavier elements (most notably carbon and silicon), which are produced in massive stars. Thus, some additional explanations for the absence of protogalaxies in deep searches are needed.

Are Quasars Hiding Protogalaxies?

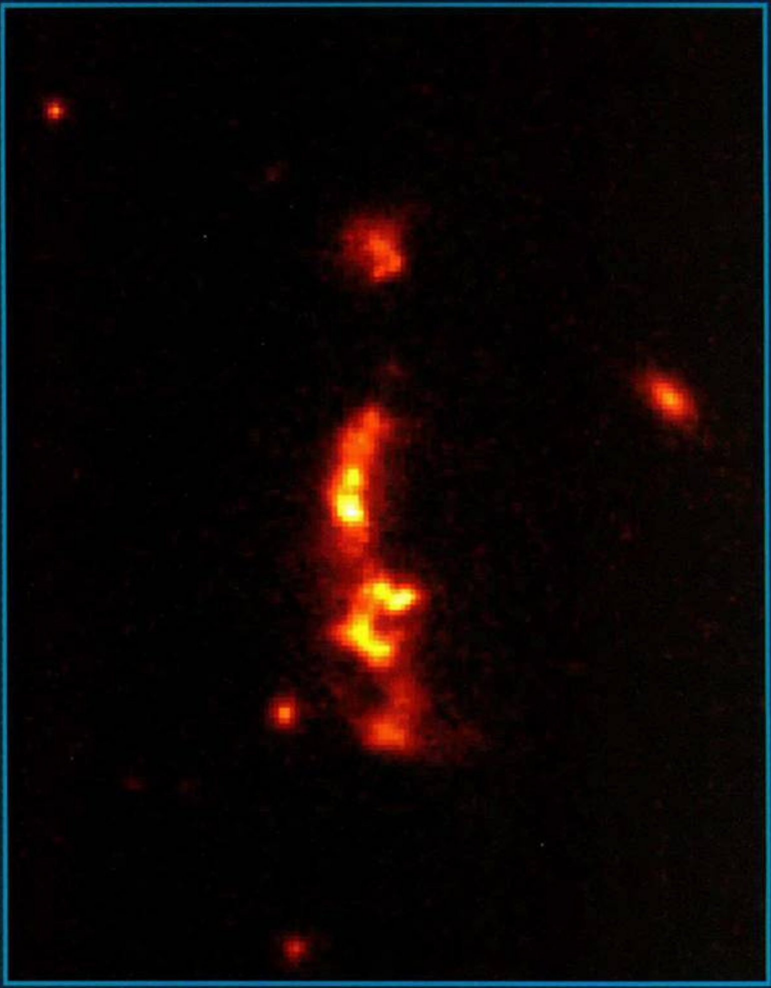
One intriguing possibility is that a population of protogalaxies has been seen, in the form of high-redshift quasars and radio galaxies. The key idea here is that nearly every young galaxy (an elliptical, or a bulge of a spiral) may have developed an active nucleus right away, and underwent a quasar phase immediately as it formed. The freshly minted quasar could easily outshine the star formation activity in its host galaxy, and thus hide it from us. Moreover, the time scales of both of these phenomena, starbursts and quasar episodes, should be similar: from a few tens to a few hundreds of millions of years. Even if the luminosity of the star-forming host galaxy was the same as its quasar, disentangling their relative contributions would be very hard; the physical origins of the luminosity may be very different, but its observable appearance would be similar.

The same processes in the early universe may be responsible both for the formation of old stars, which constitute the bulk of the mass we see in elliptical galaxies and the bulges of spirals, and for the formation and feeding of supermassive black holes in their nuclei, which astronomers think power quasars. In particular, the falling of primordial gas and gas-rich protogalactic fragments into the central regions of newly formed galaxies may be essential. There, gas may get



S.G. Djorgovski, Palomar Observatory

THE ORION NEBULA in our own galaxy consists of brightly glowing interstellar gas illuminated by newly formed stars. This may be a miniature version of what happened in young galaxies, wherein millions of stars may be born at the same time.



THE RADIO GALAXY 3C 324, with a redshift of 1.2, may glow across a span of 10 billion light-years. This Hubble Space Telescope image shows the galaxy as a chainlike structure aligned with radio jets that emanate from its nucleus, which probably harbors a black hole. The jets, in turn, may be stimulating star formation.

M. Dickinson, STScI/NASA

compressed into star-forming clouds or fall towards the central black hole, if one is indeed present.

Therein lies the possible quasar-protogalaxy connection. In both cases, large amounts of gas have to be dumped quickly into a small volume, usually near the galaxy's center. Compressing interstellar gas clouds makes them unstable, and forces them to fragment and collapse, thus making stars. Some of the resulting dense star clusters may undergo a gravitational collapse, which could produce a massive black hole in the core of a young galaxy. Once a massive black hole exists, it can be fed by a further infall of gas, with the waste heat released as quasar radiation in its many observed forms. What makes quasars "quase" is an efficient supply of fuel reaching the central engine, and the infall of gas from a messy star-forming region in a young galaxy seems to be just the ticket.

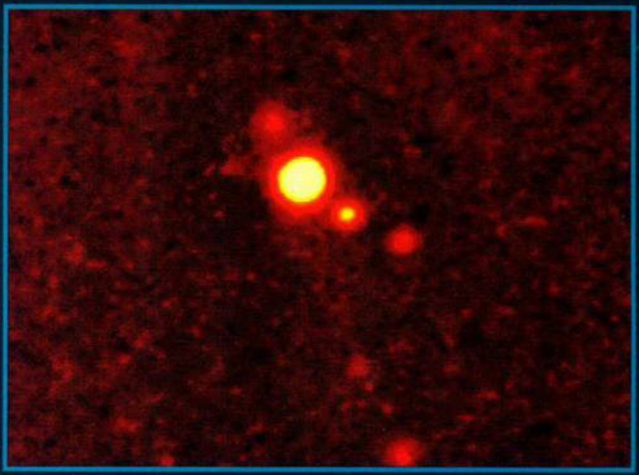
Galaxy collisions and mergers provide an excellent way to fuel quasars. Such processes exist even in the local universe, but they must have been much more frequent in the early universe, when galaxies were closer together. Observational evidence now implicates galaxy collisions and interactions in powering the starbursts and active galactic nuclei. Galaxies undergoing bursts of star formation or containing active nuclei that are sufficiently close to us to be studied in some detail tend to be distorted and appear to be interacting with nearby companion galaxies. These may be miniature versions of what was much more common in the early universe, when galaxies were forming and quasars started appearing.

Modern computer simulations of colliding galaxies show the gas promptly sinks to the middle of the merging system, where it could stimulate starburst activity, help form an active nucleus, or feed it if one is already present. Forming ellipticals and bulges probably involved a great deal of merging of gaseous bits and pieces, resulting in star formation.

Another, more subtle reason to believe in a fundamental relation between the high-redshift quasars and protogalaxies comes from spectroscopy. Strong emission lines of elements such as carbon, oxygen, nitrogen, silicon, and even iron, are visible in the spectra of most distant quasars known. Because the Big Bang produced only hydrogen and helium and astronomers see heavier elements in these spectra, the distant quasars must be associated with protogalaxies that are producing stars.

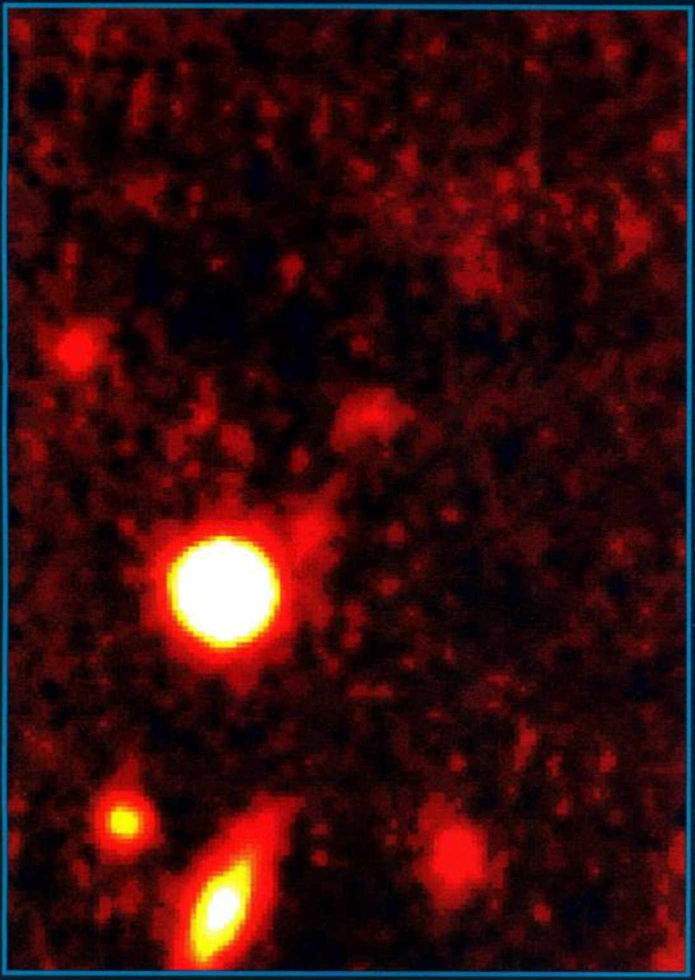
Sleeping Monsters

It's natural to expect that every sizeable galaxy harbors a massive black hole in its center, regardless of whether it is active today. Such *dormant* quasars have been detected indirectly in the nuclei of many nearby galaxies. These slumbering quasars induce rapid motions in the surrounding stars and gas, which can be measured even if there is no obvious quasarlike activity going on. Stars near a supermassive black hole must move faster in order to balance its strong gravitational attraction. Such a rapid increase in stellar motions has been detected near the centers of several nearby galaxies, including the Andromeda Galaxy.



S.G. Djorgovski and G. Meylan, ESO

THE BINARY QUASAR PHL 1222 may mark an interacting group of possibly young galaxies at a redshift of 1.9, some 10½ billion light-years away. We may be seeing the birth of two quasars about 70 percent of the way back to the Big Bang, when quasars were most numerous.



S.G. Djorgovski, Palomar Observatory

AN INTERACTING GALAXY-QUASAR PAIR, PKS 1614+051, has a redshift of 3.2, placing it 12 billion light-years away. The companion galaxy (faint object near center) is separated from the quasar by about 150,000 light-years, about the same gulf that separates our galaxy from the Magellanic Clouds.

Doing a census of the known quasars and other active galaxies at high redshifts indicates that the density of their remnants today is such that an average galaxy should contain a central black hole of about ten million solar masses. Simply by adding up the known quasars out to redshift 5 or so, and making some reasonable assumptions about how long quasar episodes may last (about 100 million years), astronomers find that to accommodate their numbers, nearly every major galaxy contained a quasar or another type of active nucleus at some time in the past. Because quasars produce energy by accreting matter onto their central black holes, astronomers can work from the total amount of energy accreted to estimate how much mass was gobbled up by black holes. On average, it comes to about 10 million solar masses per galaxy. Some quasars may have no black hole; others may have a hundred million solar-mass black hole, depending on their formation history. Some galaxies may undergo repeated episodes of quasarlike activity, depending on their feeding habits: A late, gas-rich merger could well wake up a dormant monster. This would account for the quasars seen at low redshifts. They would be rejuvenated, rather than young.

As for our own galaxy, arguments still range, but it is possible that a million solar-mass black hole lurks in its center. We may find out some day, if a nice gaseous morsel falls in it. If this happens, stock up on really good sunscreen lotion and consider moving to Alaska! Our very own quasar, which would be in the southern constellation of Sagittarius, would probably generate a lot of intense ultraviolet, X-ray, and gamma-ray radiation, in addition to being great (if brief) fun for astronomers. In our sky, such a quasar would appear as an intense, blue-white star in Sagittarius probably outshining Venus at its brightest.

Toward the Age of Galaxy Formation

In quasars, two major problems of cosmology become one and help explain each other. The formation of quasars may have followed closely the formation of their host galaxies. Protogalaxies are there, but may be lost in the glare of their exuberant young active nuclei. The most distant quasars known may signal the appearance of the first galaxies. They mark the possible sites of early galaxy formation, or even the first proto-clusters of galaxies.

Although appealing, this scenario is by no means a finished story. New data from large telescopes such as the Keck, or space observatories such as the Hubble Space Telescope, may help us begin to solve the puzzle of the origins of galaxies and quasars. They are bringing us ever closer to understanding these fundamental questions of cosmology. □

S. George Djorgovski is associate professor of astronomy at California Institute of Technology in Pasadena. He is working on the questions of formation and evolution of galaxies and quasars using the telescopes at the W. M. Keck and Palomar observatories.

How To Beat Light

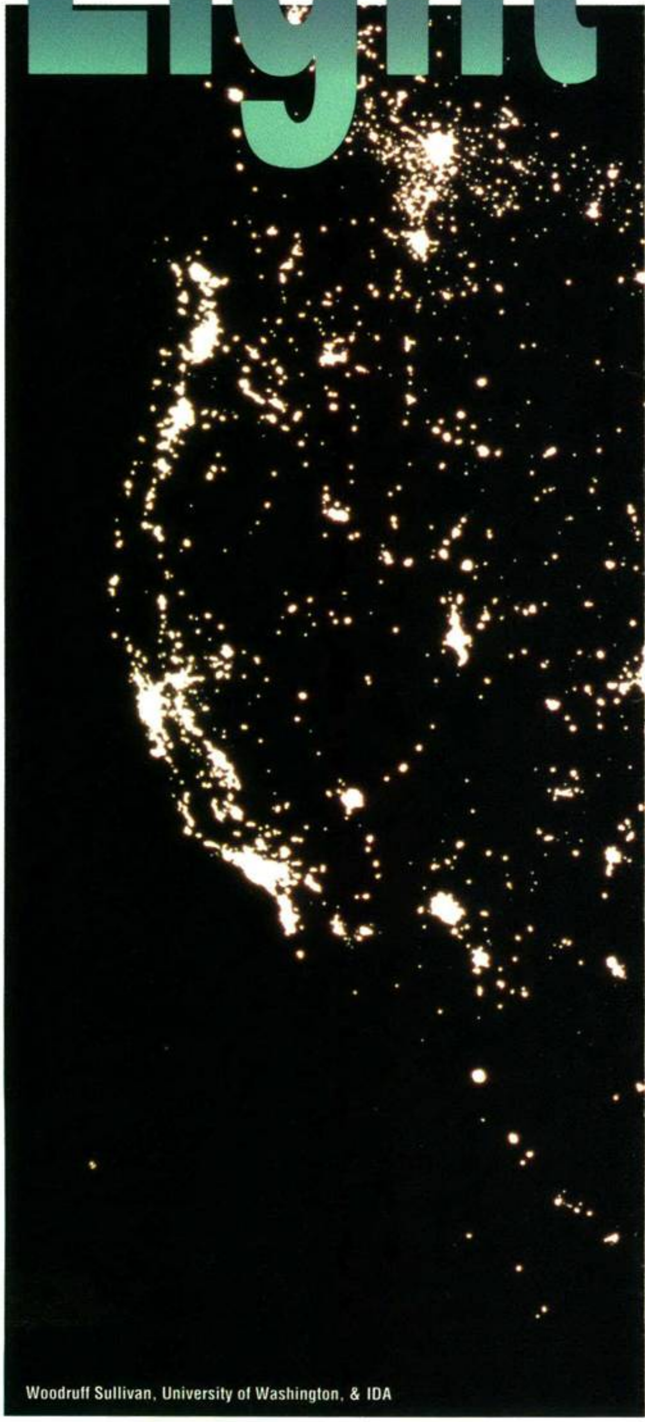
Although the battle against light pollution still rages, many recent skirmishes have been won by the forces of darkness.

by Robert Bunge

Long-time skygazers have noticed that over the years, the night sky has been growing brighter and brighter. And the universe, at least as seen from planet Earth, has been fading from view behind the glare of outdoor lighting.

Each year, as more houses are built, cities slowly expand, and communities install more powerful street lights, the darkness of the night sky suffers. Once, where human eyes could see literally thousands of stars, now they often can spot only the planets and a few of the brightest stars. Once, where the star-studded vault of the heavens served as a perfect backdrop for children to learn the lore of their forefathers, now the richness of the night sky appears only in the dome of a planetarium — for those lucky enough to have access to one.

But there is good news, a darkness at the end of the light-pollution tunnel. Although the damage done by some types of pollution can take

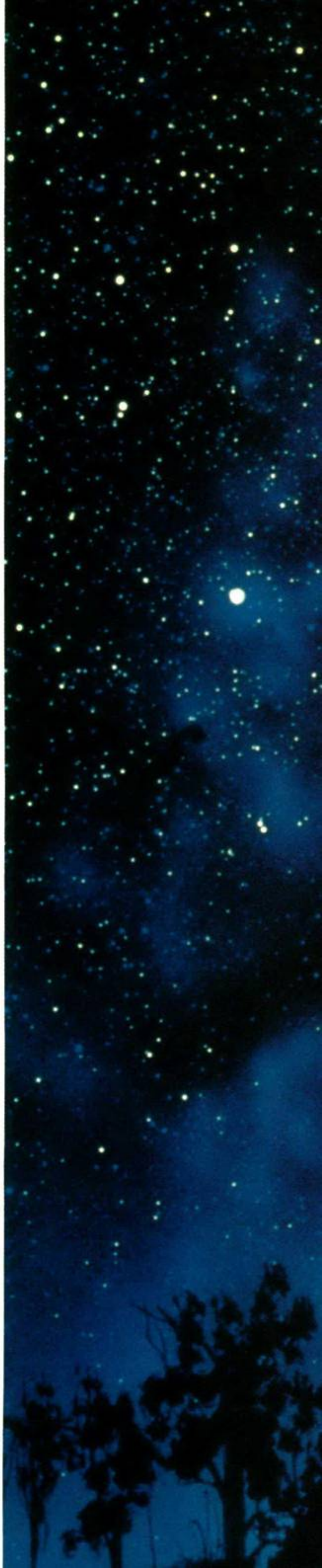


Woodruff Sullivan, University of Washington, & IDA

NORTH AMERICA FROM SPACE shows the problem faced by backyard astronomers across the continent — too much light escaping into the sky from too many locales. The result for too many is a universe that disappears behind a haze of light.

IDA, artwork by Joe Bergeron

Pollution



IDA, artwork by Joe Bergeron

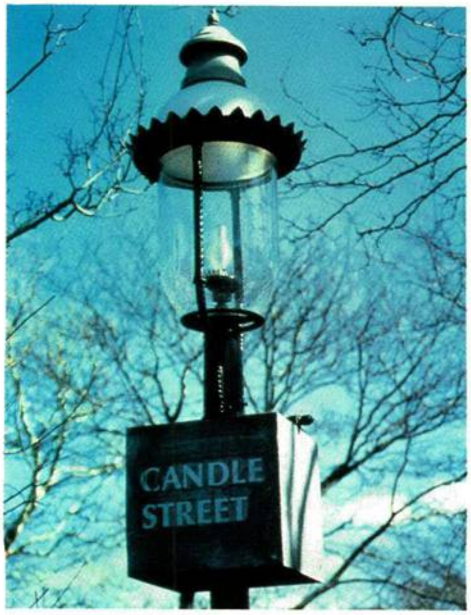
years or even decades to reverse, replacing bad light fixtures can restore the night sky to near its original splendor in short order. Moreover, "ordinary" people can have an extraordinary impact by simply getting involved in the battle. Already a few individuals and groups across the United States and around the world have started the long, difficult task of educating community leaders, power companies, lighting fixture manufacturers, lighting engineers, and the public about light pollution.

And the best news is that it all makes sense. Solving the light pollution problem not only saves the night sky for all to enjoy, but saves money for communities, businesses, and households. It also results in a more pleasant, safer, and easier-on-the-eye environment. Unwanted glare is removed, and driving on rainy streets becomes easier.

"When good lighting is used, the nighttime environment is less trashy," says astronomer David Crawford of the Kitt Peak National Observatory in Tucson, Arizona. Crawford is the executive director of the International Dark-Sky Association (IDA), a group that includes thousands of astronomers, lighting designers, environmentalists, and just plain folks who are interested in saving the night sky.

Crawford's IDA has produced a series of handouts that help educate members and the public about light pollution and lighting in general. (See "For More Information" on page 45.) As a result, more astronomers, both amateur and professional, are joining the fray. They have started working with city, county, and state governments, as well as developers and city planning professionals, to help curb excess and unwanted nighttime lighting.

GOOD LIGHTING can come in any shape and style. This streetlight on Nantucket Island may look antique but its light source lies up in the fixture, so no glare is produced and no light escapes up.



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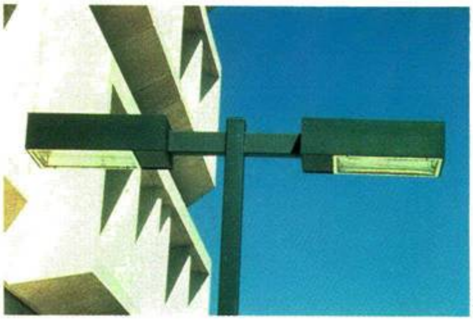


IDA

DIRECTING LIGHT DOWN is the purpose of the full-cutoff fixture. Such fixtures light the ground and not the sky, and save electricity because lower-wattage bulbs can accomplish the same lighting job.

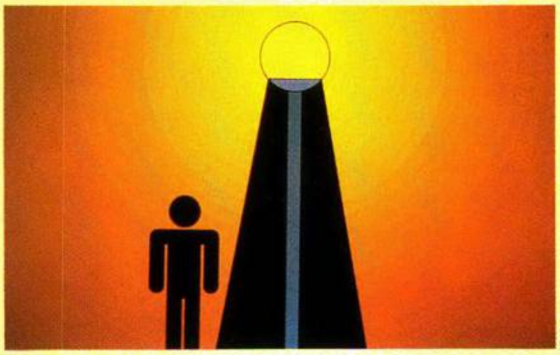
"I don't think there is a nighttime lighting program for engineers in any college in the United States," says David Oespar, an Iowan amateur astronomer turned semiprofessional lighting consultant. In the process of educating city politicians and planning officials, Oespar has learned that — thanks to IDA handouts and some homework done in local libraries — he often knows more about nighttime lighting than the lighting pros. "Few professional lighting consultants in this part of the country specialize in outdoor nighttime lighting," he states. This means that if you do your homework, you'll be able to talk to these people on a more peer-to-peer level instead of a person-off-the-street-to-professional level. You can know just as much, if not more, than they do about good lighting approaches.

The best way to get started is by reading the IDA information sheets. Second, a trip to many college libraries will be rewarded with magazines targeted toward lighting professionals, such as *L D & A* (for Lighting, Design, and Application) published by the Illuminating Engineering Society of North America. Although these magazines don't specialize in nighttime lighting, they often have articles that discuss it. By reading some of the articles, it's possible to pick up on the typical concerns of lighting professionals, their methods of operation, and trade terms. Knowing these will help greatly if you find yourself sitting across a table from one of these professionals, discussing the relative merits of full cutoff and semicutoff street lighting or the difference in color rendering between low-pressure sodium lamps and metal-halide lamps.

Crawford firmly believes that education is the biggest weapon for fighting light pollution. That means teaching people about

The Fight for Good Lighting

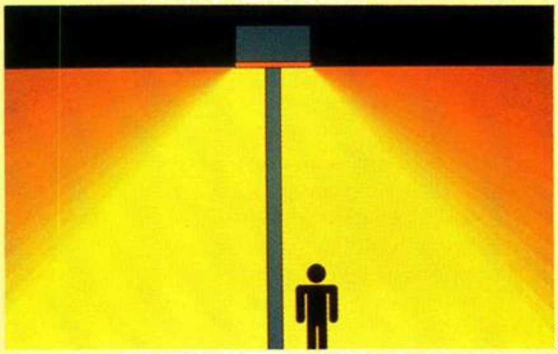
Ask most people their opinion about nighttime lighting and you'll probably get and answer something like: "The more light, the better." But just as taking too much medicine can lead to an overdose, too much lighting often proves counterproductive. It creates glare that makes things *harder* to see, forms harsh shadows that afford good hiding places and thus *decrease* safety, and sends countless photons streaming where they are *not* wanted or needed.



IDA

GLOBE FIXTURES WASTE more than half the light they produce, sending it skyward or horizontally where typically no light is needed.

The aim of light-pollution control is not to abolish all lighting but to use only as much light as needed to perform the task at hand. Well-lit streets, parking lots, and walkways are in everyone's best interests. Common sense argues, however, that the best way to achieve good lighting is by directing light toward the ground and not toward the sky.



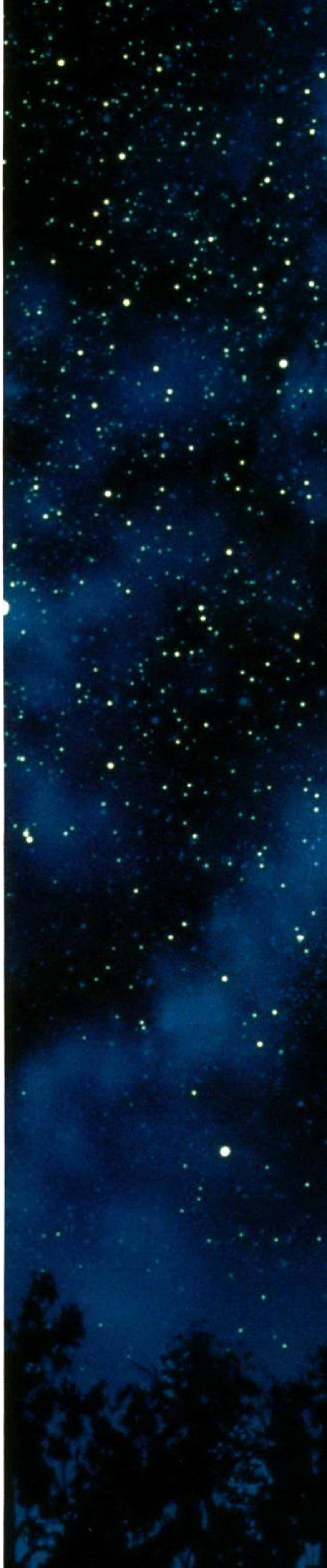
IDA

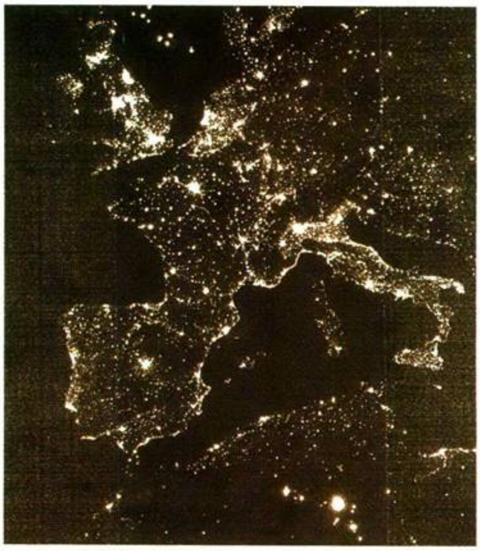
FULL-CUTOFF FIXTURES PROVIDE excellent lighting by directing the light where it does the most good — toward the ground.

Among the worst offenders are poorly designed lighting fixtures and unshielded lights. Streetlights with partial shields or, even worse, no shielding at all (like the globe fixture shown above), scatter light in all directions. Some of the light reaches the ground, of course, but just as much escapes out the sides and the top. Unshielded, all-night security lights — the bane of many suburban and rural backyard astronomers — throw light into neighbors' yards and apparently do little to improve security. Inefficient lighting wastes energy and, in the United States alone, billions of dollars every year.

One solution is to make use of fully shielded lighting fixtures, called full-cutoff fixtures. These direct all the light toward the ground so none escapes out the sides or into the sky. In such a fixture, the bulb can be seen only from directly under the lamp. It's easy to recognize lights with full-cutoff fixtures on a foggy night, when you can see the cone of light angling toward the ground. Besides reducing unwanted skyglow, fully shielded fixtures save money because lower wattage bulbs (which use less electricity) can deliver as much light to the ground.

Another way to combat light pollution is by using low-pressure sodium (LPS) lights. Professional astronomers particularly like LPS lights because they emit almost all their light at one narrow wavelength in the yellow part of the spectrum, so it can be filtered out easily. (High-pressure sodium, mercury vapor, and incandescent lights all emit at a broad range of wavelengths.) Even better, LPS lighting costs less to operate so it saves money. The bottom line? To minimize sky glow while still supplying enough illumination, choose fully shielded, low-pressure sodium lighting.





Woodruff Sullivan, University of Washington, & IDA

DENSELY POPULATED WESTERN EUROPE fares little better than North America, though note the effect of different lighting policies in France from those in Belgium, Holland, and the United Kingdom. The oil fields in the North Sea and North Africa also appear prominent.

the problem. They need to realize that a light fixture designed to allow some, or even a large portion, of its light to escape upward is not illuminating the ground efficiently. And that every photon directed toward the stars is essentially wasted, contributing to higher energy costs and greater air, land, and water pollution.

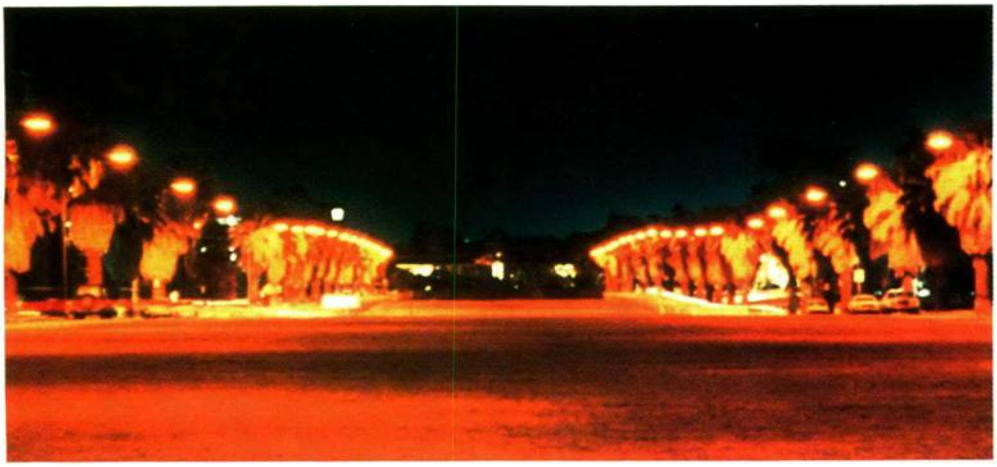
Oespar has helped educate the people of Ames, Iowa, by talking to community groups and addressing the city council. Although some people may feel too nervous going before the city council, talking one on one to the city planners can be very rewarding. You will often find that they have never even heard of light pollution. In this day of ever-tightening budgets, it's even more likely that they will be keenly interested in hearing how they might be able to reduce their annual power bill.

A different approach to education was taken by Bill Burton of the Northern Virginia Astronomy Club (NOVAC). After noticing that the monthly learning section of the *Washington Post,* called *Horizon,* was conducting "Reader Research" projects, Bill worked with *Horizon* editors to conduct the first-ever mapping of light pollution in a major metropolitan area. More than 1,200 readers of *Horizon* took a star map of Orion outside and simply counted the number of stars they could see on certain nights. Readers then reported their star counts. NOVAC members monitored the sky and picked only good nights to study. They then turned the address of each respondent into a latitude and longitude and plotted the number of stars seen.

Reporting on the results a month later, Burton was able to show (or more accurately, teach) the readers of *Horizon* what backyard astronomers already knew: People who live farther from cities can see more stars. In the process, hundreds of people — schoolchildren and adults alike — learned about light pollution, dark adaptation, where to find Orion, and how their neighborhood compares with the rest of the region. The results also held a few surprises. Although the outer, more rural regions were uniformly dark and the inner-city area was uniformly light, the suburban areas showed a tremendous scatter in the number of visible stars. This indicates that *local* lighting effects — like a nearby

IDA

BAD LIGHTING IN ACTION on the main mall at the University of Arizona in Tucson. This area had been lit with 400-watt mercury vapor lights, which produced enough light on the street but also created underlit regions, harsh shadows behind trees and bushes, and lots of glare.



IDA

AFTER UPGRADING to low-pressure sodium, the lighting on the mall improved everywhere (in the formerly dark areas by over a factor of ten) and glare and harsh shadows were banished. The university also saved money because the new 135-watt lamps used two-thirds less electricity.

ball field or shopping center — can greatly affect one stargazer while another one half-a-mile away might hardly be affected.

Across the United States, amateur astronomers are educating their local officials and starting to combat light pollution. A glance at the IDA newsletter reveals a number of heartening stories. The county schools in Hillsborough, Florida, have started a "Darken Schools" program during which they black out campuses at night. According to David Friedberg, director of security services for the schools, arrests have gone up while incidents of burglary and theft have dropped. Police say that they now can spot intruders because their flashlight beams attract attention. And groups of kids aren't drawn by the lights, so vandalism has decreased. Palos Park, Illinois, a suburb of Chicago, has been developing an ordinance to control nighttime lighting. The reason? To help preserve the rural nature of the town and maintain the quality of life that residents have come to expect.

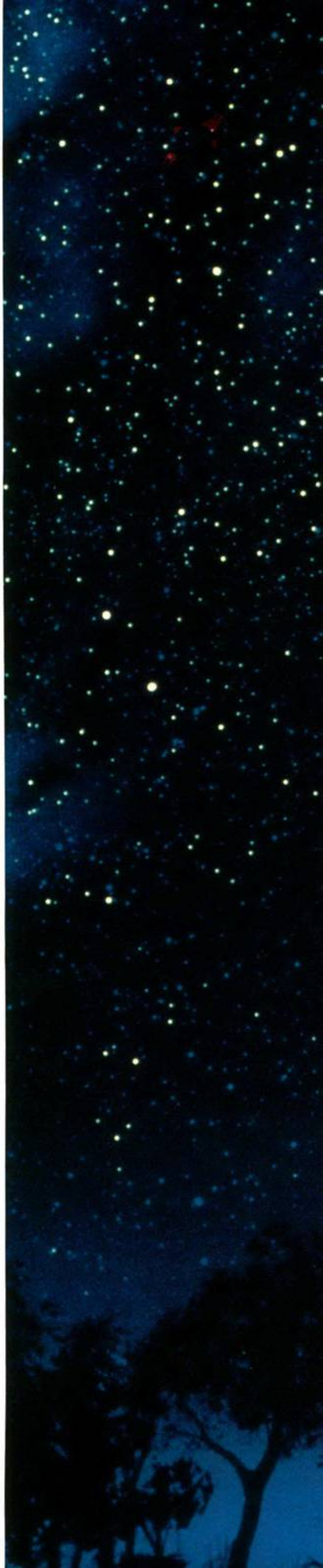
Because of the education efforts of Crawford and IDA, lighting manufacturers are producing better light fixtures and, perhaps more importantly, are making these fixtures available to cities, towns, and counties across the nation. Recently, Hubbell Lighting, Inc., came out with a kit to retrofit the classic 175-watt "cobra" head fixture. It has been estimated that more than 10 million of these lights hang from poles, houses, barns, and sheds throughout the country. For the one-time cost of about $45, the light can be refitted with a shield that turns the dreaded fixture into a full-cutoff fixture and a 70-watt lamp. Because the light is directed down, the same amount of light still reaches the ground, while the lamp's owner reaps multiyear savings without losing any effectiveness.

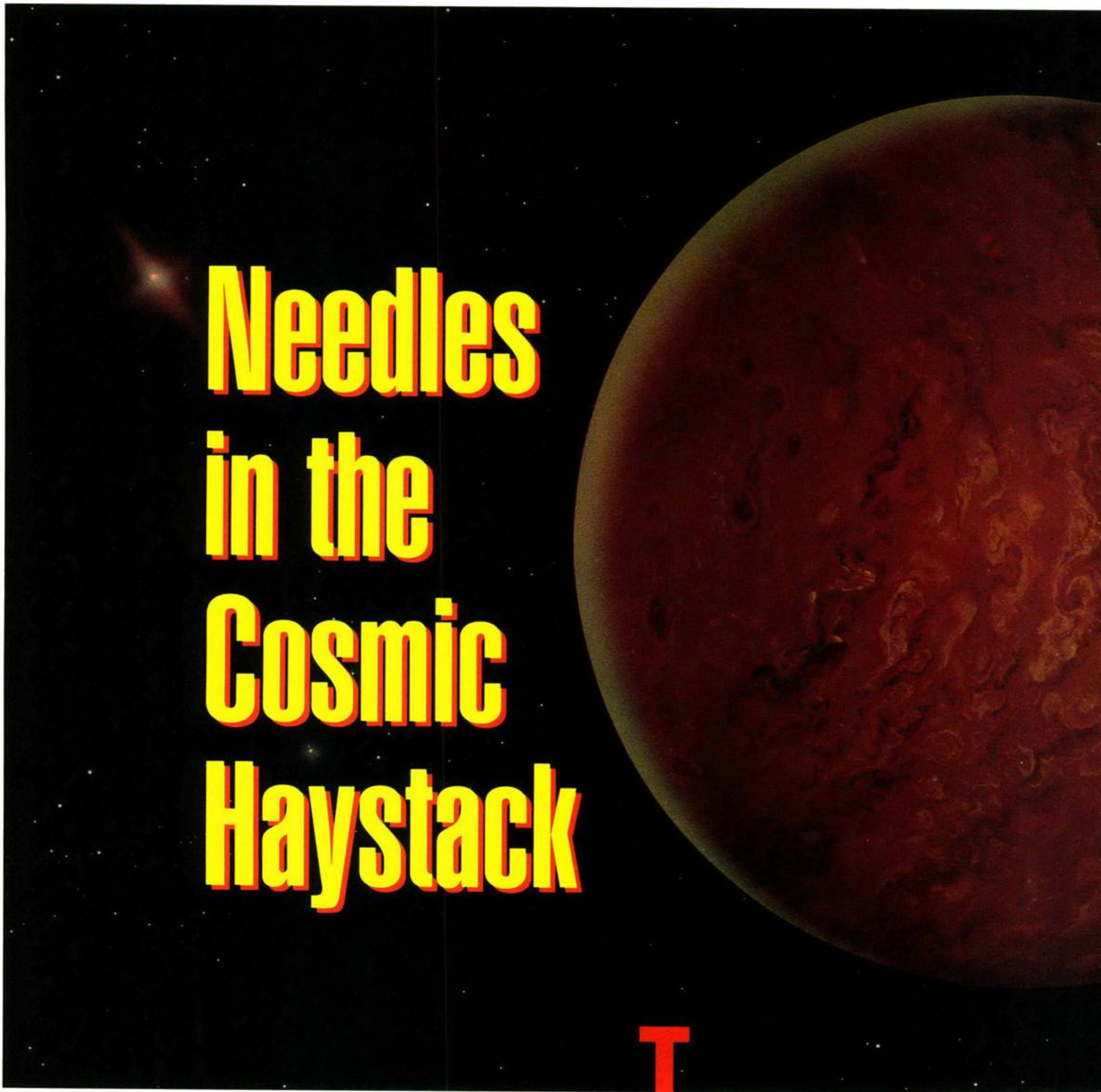
Despite all the progress, Oespar and Crawford are quick to say that there is much, much more to be done. As D. J. Campbell of Bowie, Maryland, recently pointed out, that city has begun to replace older lamps with higher wattage lamps without upgrading the fixture, a response to a series of rapes over a period of several months. "My house, across the street from one of these lights, has instantly gotten All Night Prison Lighting." Campbell considers this to be a violation of his property rights, civil rights, and constitutional rights. And it's the type of violation just waiting to happen again and again if knowledgeable citizens don't take up the fight. □

For More Information

In its effort to educate people about light pollution, the International Dark-Sky Association provides, at cost, slides and information sheets to its members and others. Seven different slide sets cover the problem of light pollution and show numerous examples of good and bad lighting. Over one hundred information sheets cover topics such as "An Introduction to Light Pollution," "Recommendations About Effective Outdoor Lighting," and "How to Talk to Your Neighbor Who Has a Bad Light." To order slide sets or information sheets, or to join IDA, write to IDA, Inc., 3545 N. Stewart, Tucson, AZ 85716.

Robert Bunge writes frequently for ASTRONOMY*. His latest article, "Big Ears" (August 1994), discussed the high-tech telescopes being used in radio astronomy.*





Needles in the Cosmic Haystack

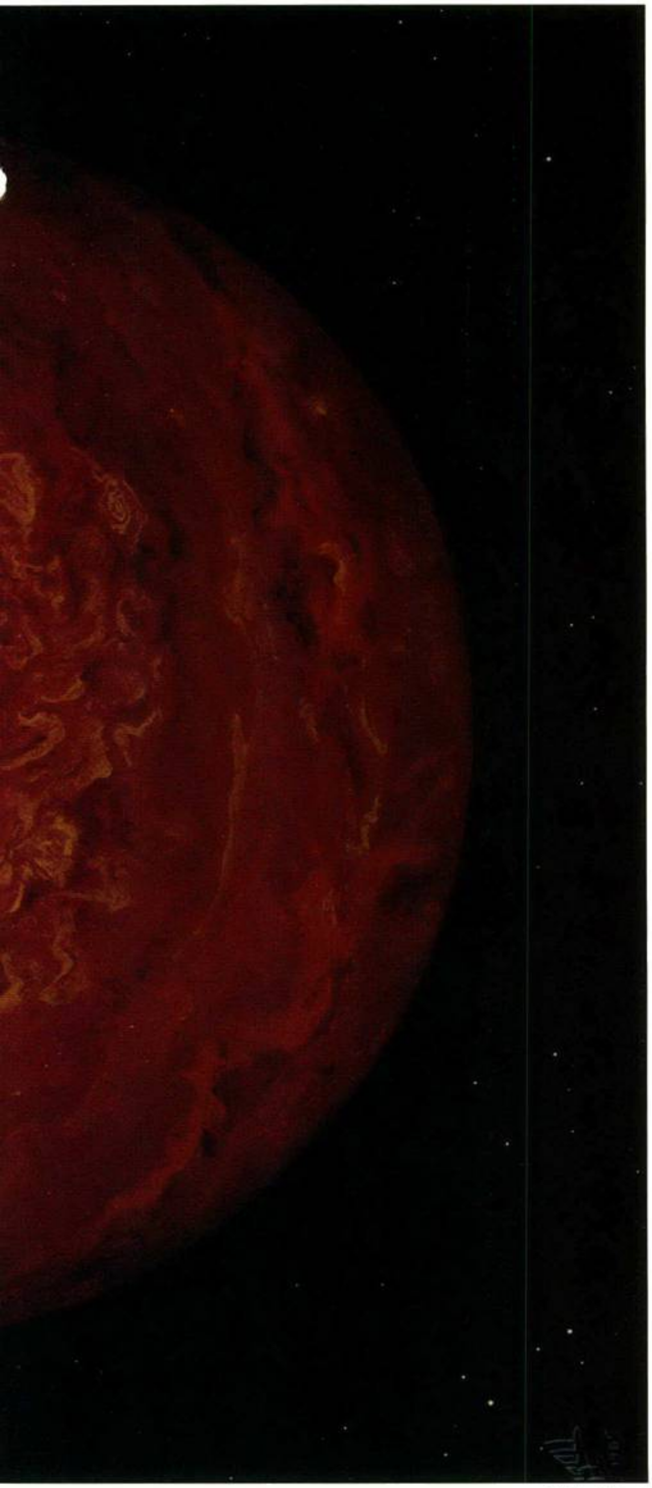
Did the universe fail to make the smallest stars or are they just too faint and elusive?

by Sally Stephens

There should be a lot of them out there. But, so far, no astronomer has found even one.

Still, the hunt continues for brown dwarfs, objects that fall somewhere between a planet and a star in size. These small objects will add to the understanding of how stars form and what goes on inside stars. They may even tell researchers what makes up the mysterious *missing mass in the* Milky Way Galaxy, the 90 percent of the Galaxy's mass that is invisible.

That is, if astronomers ever find one.



Michael Carroll

The lack of discoveries of these supposedly plentiful objects is beginning to concern astronomers. Perhaps computer models of how stars form are wrong, so instead of billions of brown dwarfs populating the Galaxy, only a few exist. Or maybe the objects are just too faint for astronomers to find them easily.

But if observers ever do find a candidate, they think they have a surefire test to distinguish faint stars from brown dwarfs. They'll look for the element lithium in its spectrum because stars destroy lithium as they generate their energy and brown dwarfs do not.

Brown dwarfs aren't quite big enough to be stars. The weight of their outer layers isn't sufficient to compress the cores to the high pressures and temperatures needed to start hydrogen fusion, the energy source deep inside stars like the Sun. In fact, any starlike object with a mass less than 8 percent that of the Sun will never become hot and dense enough in its core to "burn" hydrogen.

Stars form when a huge cloud of interstellar gas and dust contracts. The cloud fragments into many smaller contracting clumps, each of which becomes a star when the energy released by the onset of hydrogen burning in its core halts the contraction. Theoretically these clumps should come in all sizes, including those too small to trigger hydrogen fusion.

Instead of becoming stars, the smallest clumps continue to contract until the pressure squeezes the electrons in the electrically charged gas close together, which provides a counterbalancing push outward that halts the collapse. By this time, they have shrunk considerably. "Brown dwarfs have sizes that are no bigger than Jupiter," says Geoff Marcy, an astronomer with San Francisco State University and the University of California at Berkeley. "They may even be a little smaller." But they're considerably more massive than the giant planet, containing up to 80 times Jupiter's mass.

Although pressures inside brown dwarfs are not high enough to trigger hydrogen fusion, they are high enough to turn gaseous hydrogen into a liquid. Surrounding the liquid hydrogen core lies a razor-thin atmosphere of gaseous molecules. There is no abrupt change from gas to liquid (as there is between Earth's air and oceans), only a gradual thickening of gas. The same thing happens deep inside Jupiter and Saturn, which both have enormous gaseous atmospheres surrounding a ball of liquid hydrogen. But unlike brown dwarfs, Jupiter and Saturn both have a rocky center.

Because they're made of the same things and are about the same size, the difference between a brown dwarf and a Jupiter-like planet is not well defined. Most astronomers distinguish the two based on how they form. While a brown dwarf forms out of the collapse of a cloud of interstellar gas and dust, a planet forms when dust in a disk around a newborn star collides, sticks together, and grows ever larger until it forms a rocky core. So although the two types of objects may look similar, their origins are very different.

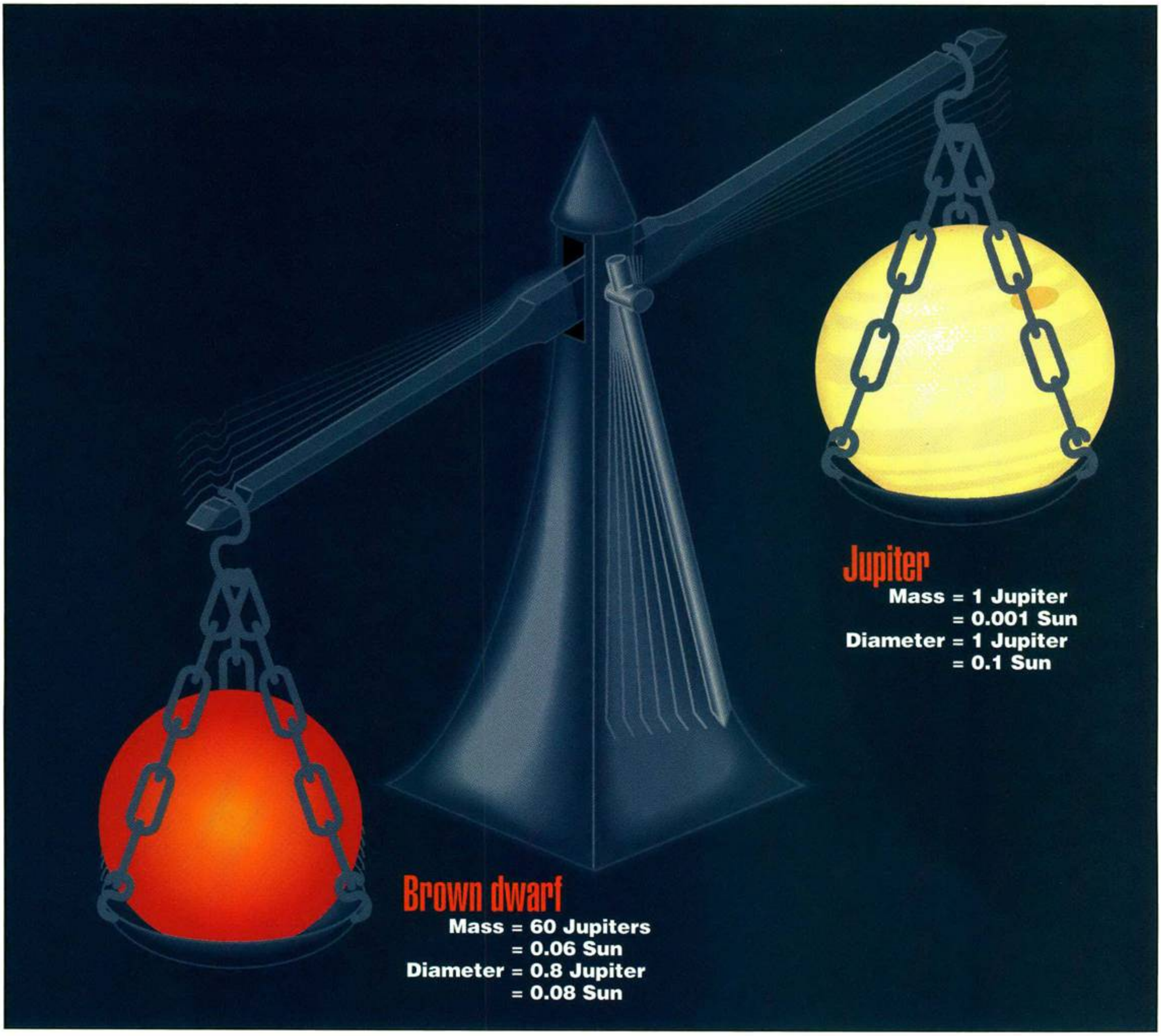
For a short time after their contraction, a young brown dwarf shines feebly as protons in its core fuse with deuterium, a form of hydrogen, and give off energy. It also glows from the gravitational energy stored during its contraction. But ultimately, with no central nuclear fire to keep it going, the brown dwarf begins to cool off and slowly fade from sight, like a dying ember.

Mary Baxter

"I think brown dwarfs are quite rare."

John Stauffer

Brown dwarfs in their cooling-off phase are probably too faint to see even in the largest telescopes. Consequently, astronomers try to find them when they're young and at their brightest. But when



ASTRONOMY, Steve Davis

BROWN DWARFS TIP THE SCALE because they are much more massive than Jupiter. The immense mass packs into a volume smaller than that of the planet.

they're young, brown dwarfs should look very much like normal low-mass stars, and figuring out whether a candidate is a brown dwarf or a star has proven difficult.

Ideally, astronomers would look for a young, intrinsically faint, cool, red object with very low mass. But in reality, they can observe only its color and apparent brightness. To narrow things down a bit, many astronomers search for brown dwarfs in young clusters whose age and distance are well known.

John Stauffer, from the Harvard-Smithsonian Center for Astrophysics, has identified a number of possible brown dwarfs in the 70-million-year-old Pleiades. He explains, "I just look for faint, red objects which have more or less the colors and magnitudes predicted by models for 70-million-year-old brown dwarfs at the distance of the Pleiades." Stauffer refers to the objects he has found as "candidate" brown dwarfs, not "real" ones.

He has cause to be careful. Over the years, researchers have excitedly reported numerous discoveries of brown dwarfs. In nearly every case, further study has shown the initial reports to be in error. Marcy says, "There's a heap of wanna-be brown dwarfs." Many of the false alarms turn out to be very-low-mass, hydrogen-burning stars, mistaken for brown dwarfs when errors were made converting their colors to temperatures.

"Because these stars are so faint and cool," Stauffer adds, "it's necessary to be very careful when one compares the observed properties to theoretical ones." In one case, temperatures of candidate brown dwarfs were accidentally underestimated by just 200 kelvins (compared to the object's surface temperature of a few thousand kelvins). When re-

The Best Brown Dwarf Candidates

Name	Location	Constellation	Magnitude
PPL 15	Pleiades star cluster	Taurus	22.4
GD 165B	Orbits white dwarf	Bootes	14 (infrared)
4 stars	Pleiades star cluster	Taurus	22
7 stars	Rho Ophiuchi star cluster	Ophiuchus	13-15 (infrared)

searchers applied the proper temperature correction, all the objects that had appeared to be brown dwarfs turned out to be normal stars.

Because it bypasses error-prone conversions, the lithium test can unambiguously distinguish between brown dwarfs and normal stars. Stars begin their lives with a small amount of lithium, most of it left over from the Big Bang that marked the beginning of the universe. "It's not very much to begin with, one part in a billion," Marcy notes.

Lithium burns at a slightly lower temperature than hydrogen does. So if hydrogen burning takes place, lithium burning must also occur, thus depleting the amount of lithium in the object. For example, nuclear reactions have reduced the amount of lithium present in the Sun a thousand-fold from its primordial value. Turning the argument around, any object that still has all its original lithium is too cool inside for hydrogen fusion to occur. It must be a brown dwarf.

"Lithium is like a thermometer shoved down the throat of a star," Marcy explains. "In fact, it's better. A thermometer would just tell you the temperature. The presence of lithium tells you that nuclear reactions are not going on in the core."

Lithium produces a telltale dark absorption line in the red end of a star's spectrum at 670.7 nanometers. If the lithium line appears in an object's spectrum, it may actually be a brown dwarf. If the lithium line doesn't appear, the candidate can't be a brown dwarf; it's a normal star.

Although the method is straightforward, actually performing the test is not easy. Brown dwarf candidates are typically very faint, necessitating long time exposures with the largest telescopes to get spectra with enough resolution to look for weak lithium lines. "At 22nd magnitude, this becomes challenging," Marcy adds.

Marcy and his colleague Gibor Basri, from the University of California at Berkeley, have used the HIRES spectrometer at the 10-meter Keck telescope in Hawaii to get high-resolution spectra of a few brown dwarf candidates. "Models [of how stars age] say that if you find lithium in a star 70 million years old [the age of the Pleiades], then its mass must be less than 0.08 solar mass," Marcy states. That would make it a brown dwarf. "We've looked at four or five from one survey of the Pleiades, and they don't have any lithium. They've burned it, so they're not brown dwarfs."

With sophisticated yardsticks such as the lithium test, astronomers have managed to disprove many candidates. But confirming one as a brown dwarf remains elusive.

Failure to find unambiguously even one brown dwarf has implications of galactic proportions. Because brown dwarfs are so faint as to be virtually undetectable for most of their lives, the Galaxy could hold a large number of them, creating an enormous reservoir of unseen matter.

Stars appear to orbit about the Galaxy's center at a much faster speed than theorists predict given the amount of stars, gas, and dust seen. The researchers suggest that the added gravitational pull that speeds up the stars comes from invisible matter located in the halo surrounding the Galaxy.

Considerable debate exists regarding the nature of this additional dark matter. Some researchers argue that the matter consists of exotic atomic particles never before seen on Earth. Others say it's ordinary matter in a form that's just too faint to be detected. For example, lots of brown dwarfs in the outermost regions of the Galaxy could account for the dark matter.

Several groups are currently looking in the outer regions of the Galaxy for brown dwarfs and other small objects. Astronomers call them massive compact halo objects or MACHOs. They look for a sudden brightening of a star in the halo or in the Large Magellanic Cloud (LMC) as its light is temporarily magnified by a compact object moving between us and the star. The compact object itself is too faint and thus remains invisible, but its gravitational effect on the background star's light is easily seen. A large number of such events would indicate significant amounts of brown dwarfs and other unseen objects.

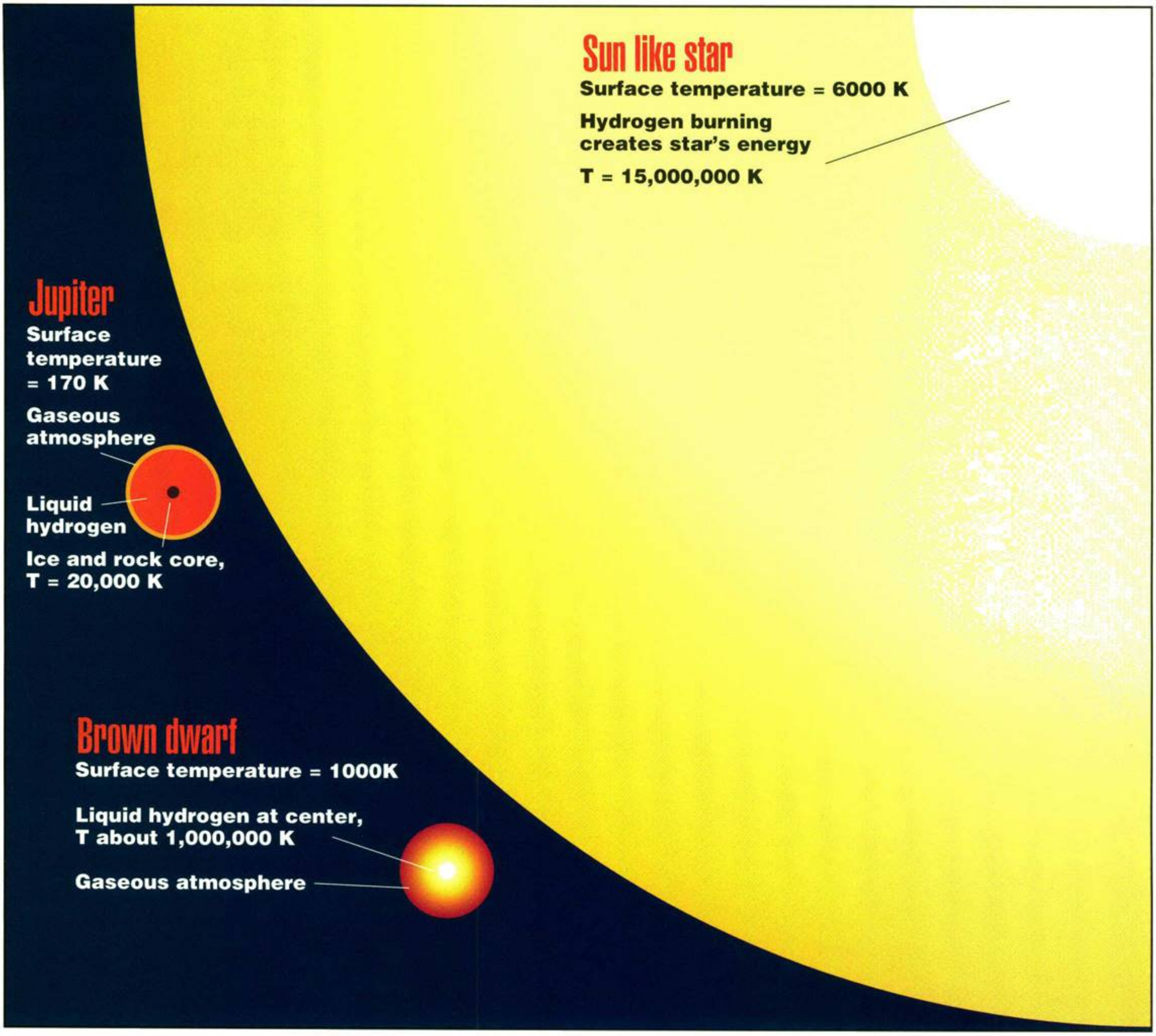
Geoff Marcy

"PPL 15 appears to be the first brown dwarf clearly identified."

Geoff Marcy (left) and Gibor Basri

After monitoring the brightness of millions of stars, astronomers so far have seen only fifty or so brightening events. Careful analysis of the observed light changes, which yields information on the masses of the MACHOs, indicates that most of the events appear to arise from objects with masses too high to be brown dwarfs. But according to MACHO researcher Kem Cook of the Lawrence Livermore National Laboratory, "analysis of three LMC events from our first year of observing suggests that they are most likely caused by brown dwarfs." Although these events point to brown dwarfs, the actual objects responsible have not been seen because they are much too distant and faint.

In any case, the number of MACHO events so far detected is less than predicted for a large spherical halo of dark matter. "If there is such a halo, it is most likely composed of only 20 percent brown dwarfs, based on our first year of LMC data," Cook says. The puzzle of what constitutes dark matter remains unsolved.


Sun like star
Surface temperature = 6000 K
Hydrogen burning creates star's energy
T = 15,000,000 K
Jupiter
Surface temperature = 170 K
Gaseous atmosphere
Liquid hydrogen
Ice and rock core, T = 20,000 K
Brown dwarf
Surface temperature = 1000K
Liquid hydrogen at center, T about 1,000,000 K
Gaseous atmosphere

ASTRONOMY, Steve Davis

THE CORE DIFFERS among stars, planets, and brown dwarfs. Planets have a rocky core and stars burn hydrogen in theirs. Brown dwarfs have a liquid hydrogen core that *isn't dense enough* to ignite nuclear fires.

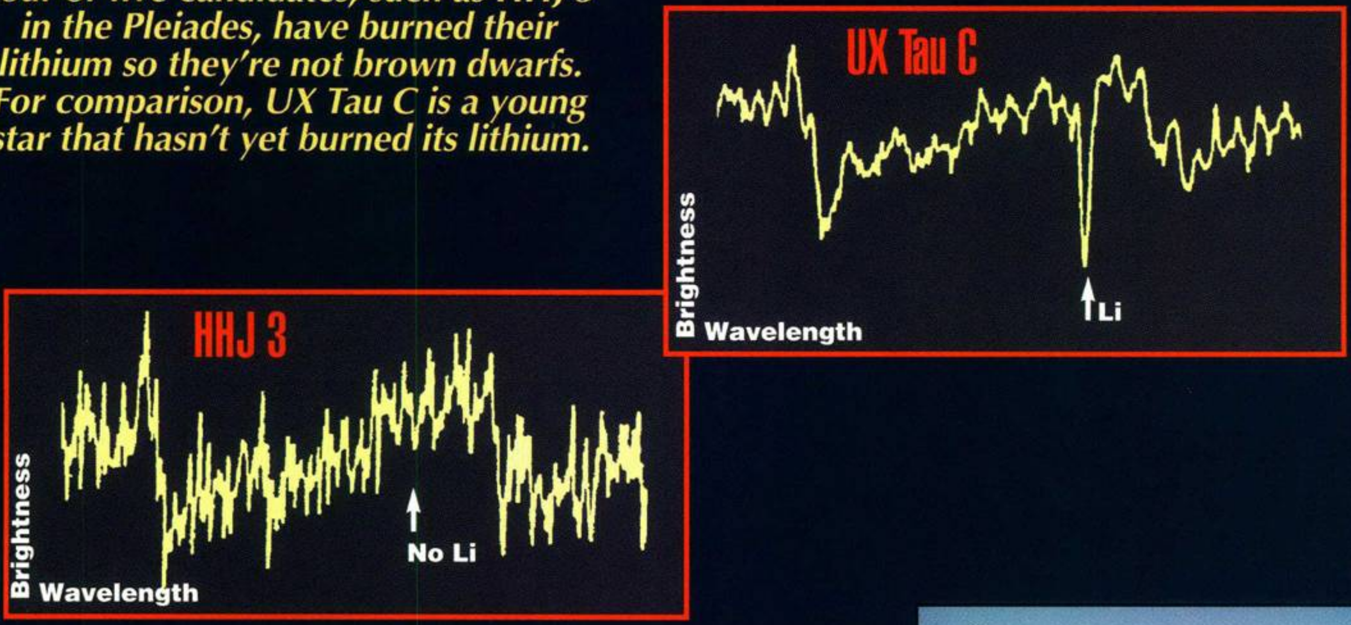
As the hunt for MACHOs proceeds, the search for brown dwarfs continues in other areas. Marcy and his colleagues monitor the motions along the line of sight of a number of stars, looking for slight irregularities that might indicate the presence of unseen low-mass companions. After ten years of observing the same stars, they haven't seen anything unusual in their velocities.

"I now realize how rare brown dwarfs are as companions to stars, at least within 5 or 10 astronomical units," he comments. (An astronomical unit is the average distance between the Sun and Earth; Jupiter is roughly 5 AU from the Sun and Saturn is just under 10 AU away.) More distant companions take longer to orbit the star, and thus the effects they have on the star's motion take much longer than ten years to become evident. Searches by Marcy and others during the next few years for planets around other stars may yield more information on the existence of brown dwarfs.

Other astronomers search for companions to stars primarily in the infrared where the cool brown dwarfs should be brightest. They discovered one of the best-known candidates, GD 165B, in this way. This object is the companion (hence the "B") of a white dwarf star called GD 165. White dwarfs represent the final stage in the lives of stars like the Sun.

GD 165B is a very faint and cool object, lying at least 120 AU from the white dwarf — three times the distance of Pluto from the Sun. Consequently GD 165B takes about 1,600 years to orbit the white dwarf. In the mere decade since the companion's discovery, observers have detected no orbital motion. If such motion were seen, it would allow

Four or five candidates, such as HHJ 3 in the Pleiades, have burned their lithium so they're not brown dwarfs. For comparison, UX Tau C is a young star that hasn't yet burned its lithium.



a precise determination of the companion's mass.

Theoretical models of stars having GD 165B's color and brightness indicate that the object may contain only 0.06 solar mass, low enough to be a brown dwarf. "I think brown dwarfs are quite rare," Stauffer states, "judging by how few good candidates have been found to date." He adds, "GD 165B is still my favorite candidate to be a real brown dwarf."

But it does have some problems. If it formed at the same time as its white dwarf companion, it would have to be billions of years old. Therefore it should have exhausted long ago whatever energy supplies it had while young. So why hasn't it faded from view?

The object's spectrum is also unusual, in that it doesn't look anything like the spectra of other very-low-mass stars. Perhaps its white-dwarf partner deposited material onto its surface during an earlier phase of its life, altering GD 165B's chemical composition and making it appear redder than it otherwise would. Or maybe strong winds earlier in the white dwarf's life blew away some of GD 165B's mass, making it appear smaller than it originally was. Both these scenarios could turn a low-mass star into an object that looks like a brown dwarf.

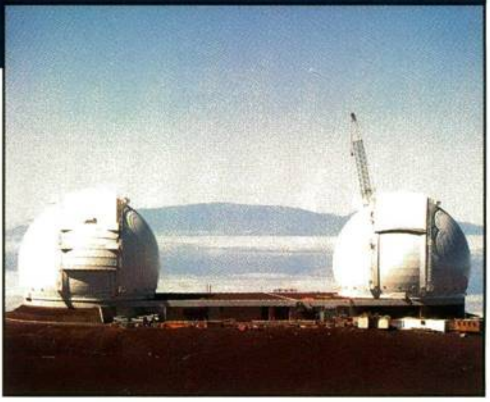
Whether GD 165B is ever proven to be a brown dwarf or not, confirmation of the first real brown dwarf may be near. Stauffer discovered the faintest star ever found in the Pleiades, PPL 15 (the PPL stands for Palomar Pleiades), using Palomar Observatory's 200-inch telescope. Marcy and Basri trained the Keck telescope on this star for a total of five hours (PPL 15 has a visual magnitude of 22.4), finally obtaining a faint spectrum. As Marcy reported at a recent meeting of the American Astronomical Society, "the spectrum of PPL 15 clearly shows a strong absorption line exactly at the wavelength where the lithium line should be. This is the definitive signature of a brown dwarf."

The amount of absorption is slightly less than that expected from stellar models. "It seems the star is in the process of burning its lithium," Marcy explains. "Nonetheless, such a star, caught in the act of burning lithium at this late stage of its life (the amount of lithium implies it is 120 million years old), will never get hot enough in its core to burn hydrogen. So PPL 15 appears to be the first brown dwarf ever clearly identified. The long search is over . . . maybe."

Basri and Marcy estimate that a small chance (about 5 percent) exists that the absorption line is simply noise in the spectrum, a result of the star's extreme faintness. The two astronomers will return to the Keck in November 1995 to obtain a better spectrum of PPL 15 in order to confirm or reject their lithium claim.

Even if PPL 15 has lithium, does that prove brown dwarfs exist? "Maybe this one object is a freak," Marcy suggests. "To do the science right, we have to go out and take spectra of several objects and make sure they all show lithium. I'm going to feel a little uncomfortable until I see a couple of them." Not until then will the hunt for the elusive brown dwarf be over. □

Sally Stephens is a science writer living in San Francisco. Her previous story, "Only Six with Rings," appeared in the April 1995 ASTRONOMY.



Andrew Perala, CARA

THE POWER of the 10-meter Keck telescope enables Marcy and Basri to obtain spectra of 22nd-magnitude brown dwarfs.

SKY ALMANAC

Skywatchers see asteroid Melpomene solo through Aquarius, glimpse a duet between Jupiter and Omega Ophiuchi, and survey a trio formed by the Moon, Mars, and Zubenelgenubi.

by Deborah Byrd

Highlights

by John Shibley

Date	Event
2	**First Views:** Explore the First Quarter Moon .... *(p. 56)*
14	A Different Opposition for Saturn .... *(p. 62)*
24	Jupiter Meets Omega Ophiuchi ..... *(p. 61)*
25	Venus Emerges Into Evening...... *(p. 61)*
27	The Moon, a Double, and the Red Planet .... *(p. 64)*
All month:	
	Following the Muse of Tragedy...... *(p. 64)*
	Observer's Challenge: Chasing Down Stephan's Quintet ...... *(p. 65)*
	The Starry Sky: Cepheus ..... *(p. 63)*

September is the month for evening planets. In fact, during this month's waning days, observers armed with sharp eyes, binoculars, and telescopes can hunt down all nine of our solar system's planets. (The Earth is a gift!)

For starters, take a look at Saturn, at its best for the whole year on September 14. On that afternoon, Earth passes between Saturn and the Sun, bringing this outer world to opposition. At opposition, planets beyond the orbit of Earth appear opposite the Sun in our sky. They rise in the east within a few minutes of sunset and, as the Sun travels below our feet making daylight for those on the other side of Earth, shine brightly all night among the stars.

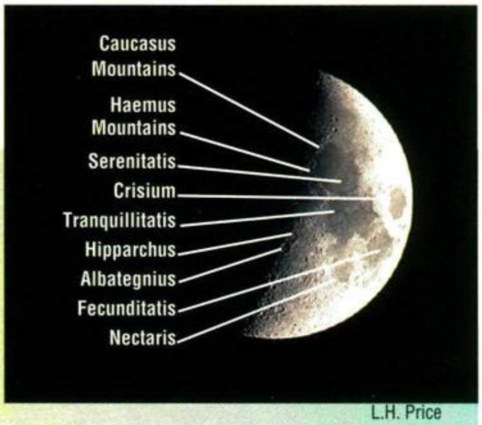
At opposition this year, Saturn shines at magnitude 0.7 among the stars of the large, dim constellation Aquarius and near two recognizable "skymarks" or asterisms. One is a faint asterism known as the Circlet in the constellation Pisces. The other is the bright star Fomalhaut in the constellation Piscis Austrinus. Saturn is located more or less in between the Circlet and Fomalhaut. It is brighter than Fomalhaut and outshines most of the stars. If you still can't identify Saturn, try looking for it near the Full Moon on September 8/9.

Most years, you can turn a telescope on this golden world to find a globe-encircling system of rings. It's a view that must have amazed our 17th-century predecessors, when telescopes became powerful enough to reveal the rings. Most people are still awestruck when they peer at Saturn through the eyepiece of a telescope for the very first time. And yet this month, as we pass between the Sun and Saturn, those who turn a telescope in Saturn's direction will have to settle for a lackluster view of the rings.

That's because, although Earth and Saturn orbit the Sun in nearly the same plane, Saturn does not stand exactly upright with respect to its orbit around the Sun. The planet's axis of rotation tilts at an angle of almost 25°. When one of Saturn's poles tilts fully our way, as was last the case in 1987, we have a grand view of the rings.

But twice in every 30-year orbit of Saturn, Earth's line of sight passes through the plane of Saturn's ring system. Then the rings appear edge-on and nearly invisible, even through powerful telescopes. No doubt the Hubble Space Telescope will provide some interesting views of Saturn's rings in their edgewise orientation this year. But for the rest of us, Saturn appears ringless

First Views:
Explore the First Quarter Moon



L.H. Price

It doesn't take much magnification, or a large telescope for that matter, to enjoy the Moon's ancient, battered surface. Grab a pair of binoculars and head outside the first weekend of September to check out a First Quarter Moon. That's when the morning terminator, an area of the Moon experiencing sunrise, runs through lunar seas, mountain ranges, and cratered highlands.

Start your tour with the maria or "seas," named when early lunar observers thought the Moon's vast, gray splotches were oceans. Today we know these maria are huge impact basins that flooded with lava billions of years ago.

On the Moon's eastern (right) limb, near the 2-o'clock position, is Mare Crisium, an oval plain measuring 270 by 350 miles. To the left, or lunar west, of Crisium is Mare Tranquillitatis. Three seas adjoin Tranquillitatis: Mare Serenitatis to the north, Nectaris to the south, and Fecunditatis to the southeast.

Two huge mountain ranges, the Caucasus Mountains to the northwest and Haemus Mountains to the southwest, make up the western ramparts of Serenitatis. They form the walls of Serenitatis' flooded impact basin.

Finally, glance west of Tranquillitatis and Nectaris to see the Moon's oldest terrain, the highlands. Two prominent craters, Hipparchus and Albategnius, straddle the terminator on Friday, September 1. This whole region bears witness to the ceaseless pounding our Moon has suffered over the last 4 billion years. — *John Shibley*

SEPTEMBER

2 The Moon passes 3° north of Jupiter, midnight EDT
First Quarter Moon is at 5:03 a.m. EDT (page 56)

4 The Moon is at perigee (228,610 miles from Earth), 9:14 p.m. EDT

5 The Moon passes 6° north of Uranus, 3 p.m. EDT

8 Full Moon is at 11:37 p.m. EDT

9 Mercury is at greatest eastern elongation, midnight EDT
The Moon passes 6° north of Saturn, 1 p.m. EDT

14 Saturn is at opposition, 11 a.m. EDT (page 62)

16 Last Quarter Moon is at 5:09 p.m. EDT

17 The Moon is at apogee (251,197 miles from Earth), 2:12 a.m. EDT

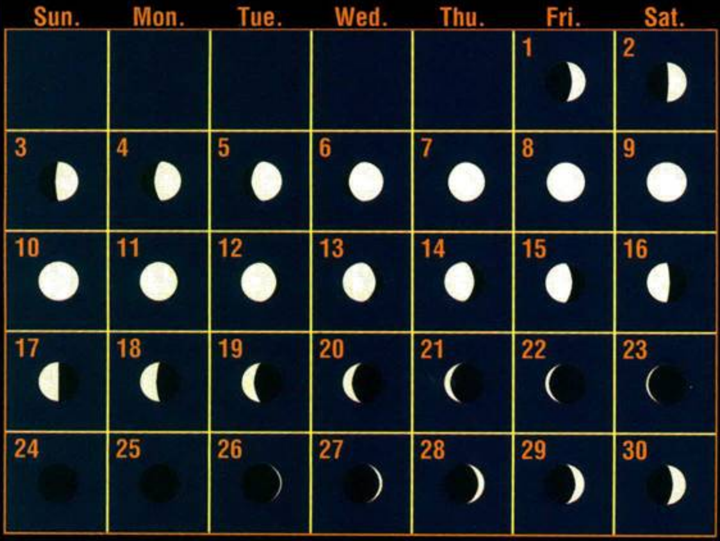
23 Autumnal equinox is at 8:13 a.m. EDT

24 New Moon is at 12:55 p.m. EDT
Jupiter passes within 1" of Omega Ophiuchi (page 61)

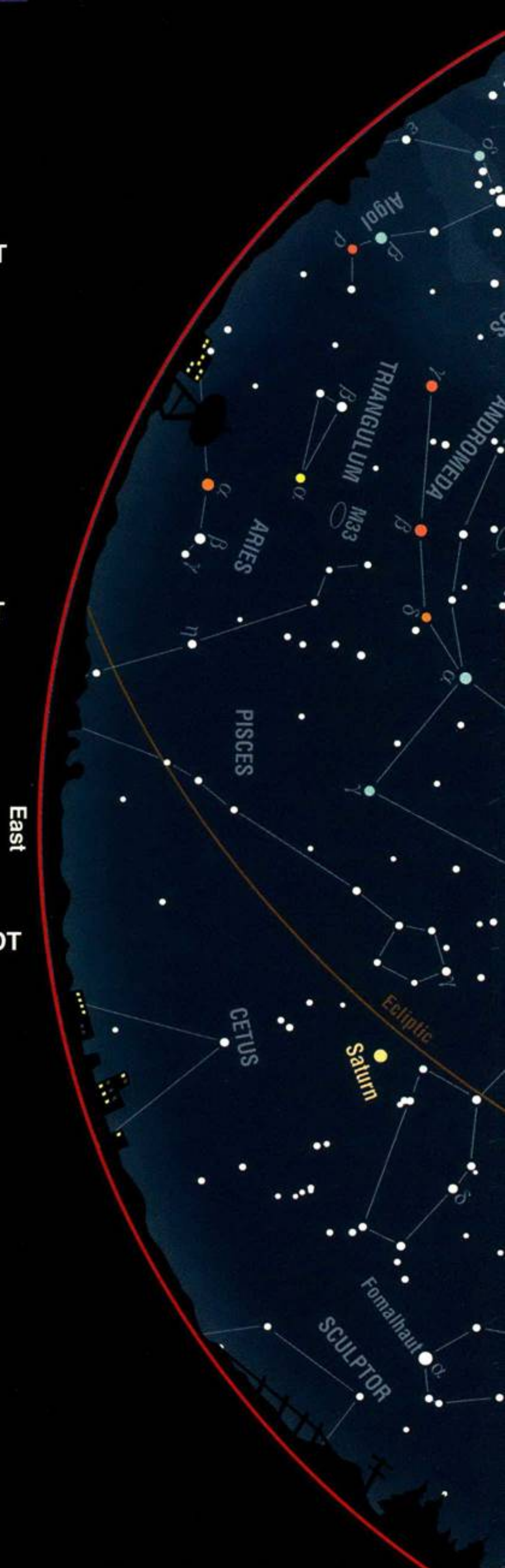
25 The Moon passes 3° north of Mercury, 7 p.m. EDT

27 The Moon passes 2° north of Mars, 2 p.m. EDT (page 64)

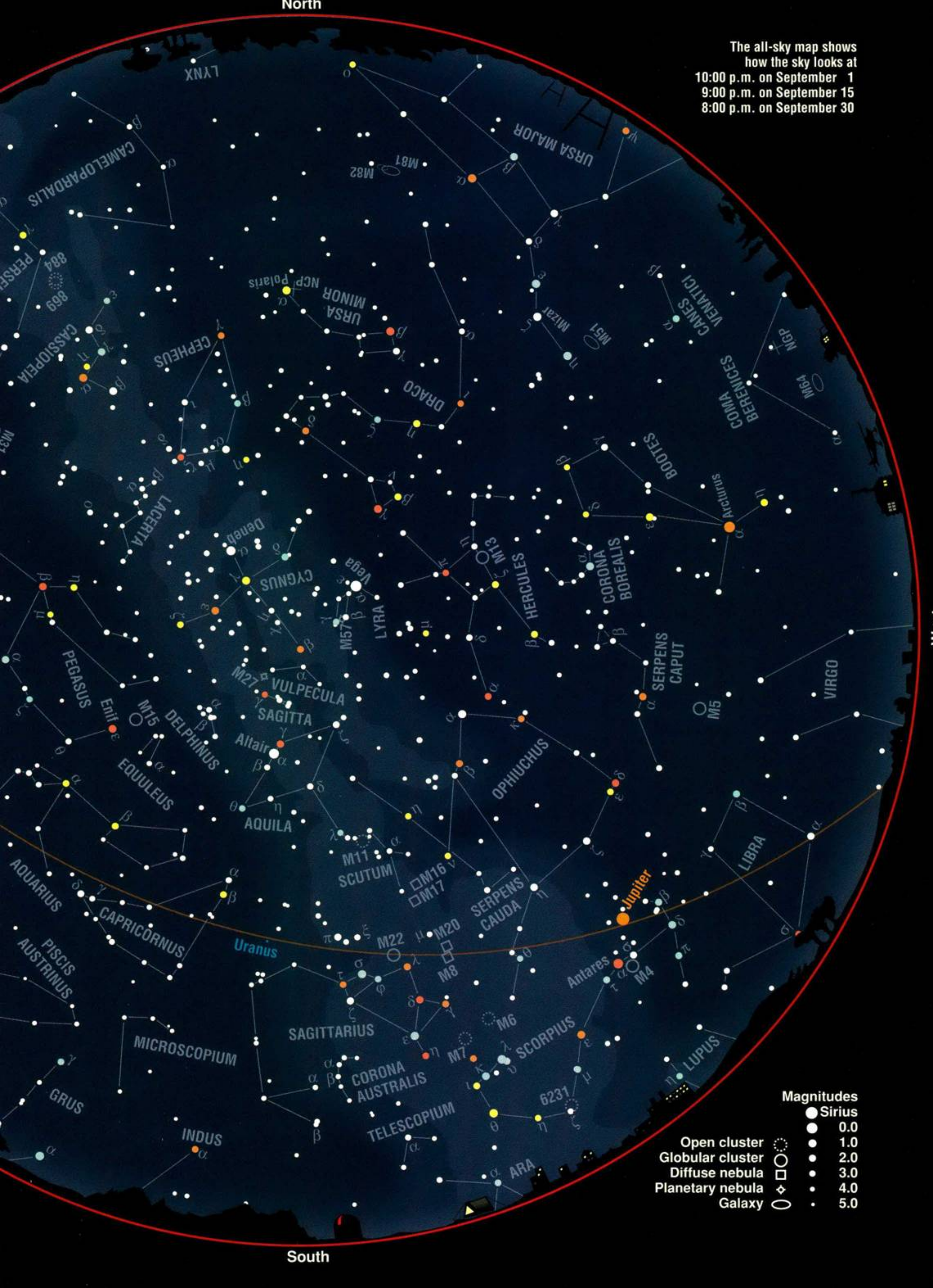
29 The Moon passes 3° north of Jupiter, 11 a.m. EDT
The Moon is at perigee (229,600 miles from Earth), 11:34 p.m. EDT



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

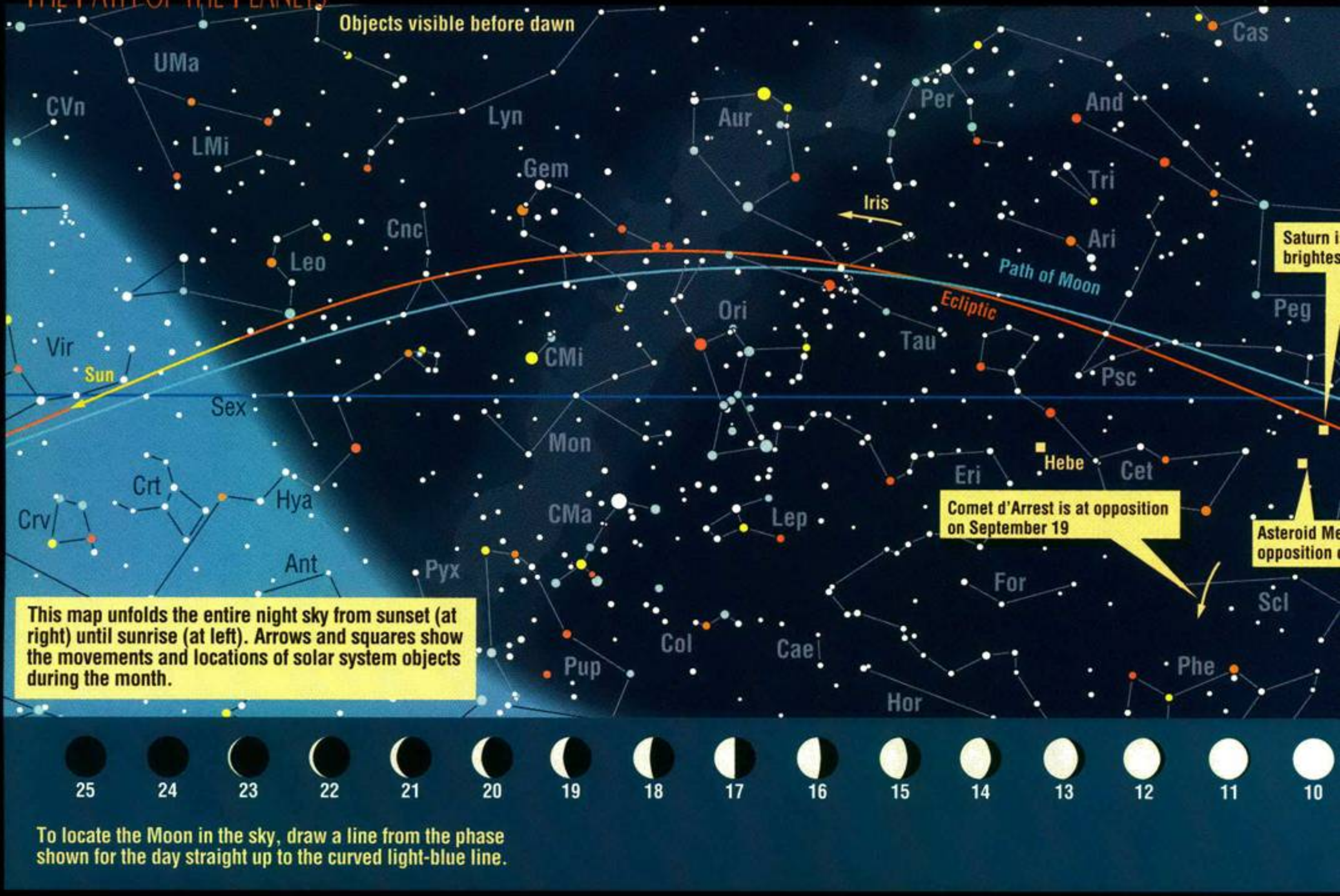


This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
LYNX
URSA MAJOR
CAMELOPARDALIS
M81
M82
PERSEUS
884
869
NCP Polaris
URSA MINOR
CANES VENATICI
CASSIOPEIA
CEPHEUS
M51
Mizar
NGP
DRACO
COMA BERENICES
M64
M31
LACERTA
BOOTES
Arcturus
Deneb
CYGNUS
Vega
M13
HERCULES
CORONA BOREALIS
LYRA
M57
PEGASUS
M27
VULPECULA
SERPENS CAPUT
West
VIRGO
Enif
M15
DELPHINUS
SAGITTA
M5
Altair
EQUULEUS
OPHIUCHUS
AQUILA
AQUARIUS
M11
SCUTUM
M16
M17
LIBRA
Jupiter
SERPENS CAUDA
CAPRICORNUS
Uranus
M22
M20
M8
PISCIS AUSTRINUS
Antares
M4
SAGITTARIUS
M6
MICROSCOPIUM
M7
SCORPIUS
LUPUS
CORONA AUSTRALIS
GRUS
6231
TELESCOPIUM
INDUS
ARA
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
10:00 p.m. on September 1
9:00 p.m. on September 15
8:00 p.m. on September 30

THE PATH OF THE PLANETS


Objects visible before dawn
UMa
CVn
LMi
Lyn
Aur
Per
And
Cas
Gem
Tri
Cnc
Iris
Ari
Leo
Path of Moon
Ecliptic
Ori
Peg
Vir
Sun
CMi
Tau
Psc
Sex
Mon
Crt
Hya
Eri
Hebe
Cet
Crv
CMa
Lep
Ant
Pyx
For
Scl
Col
Cae
Pup
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Hor
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10

Saturn i
brightes

Comet d'Arrest is at opposition on September 19

Asteroid Me
opposition

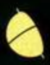
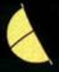
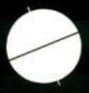
This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

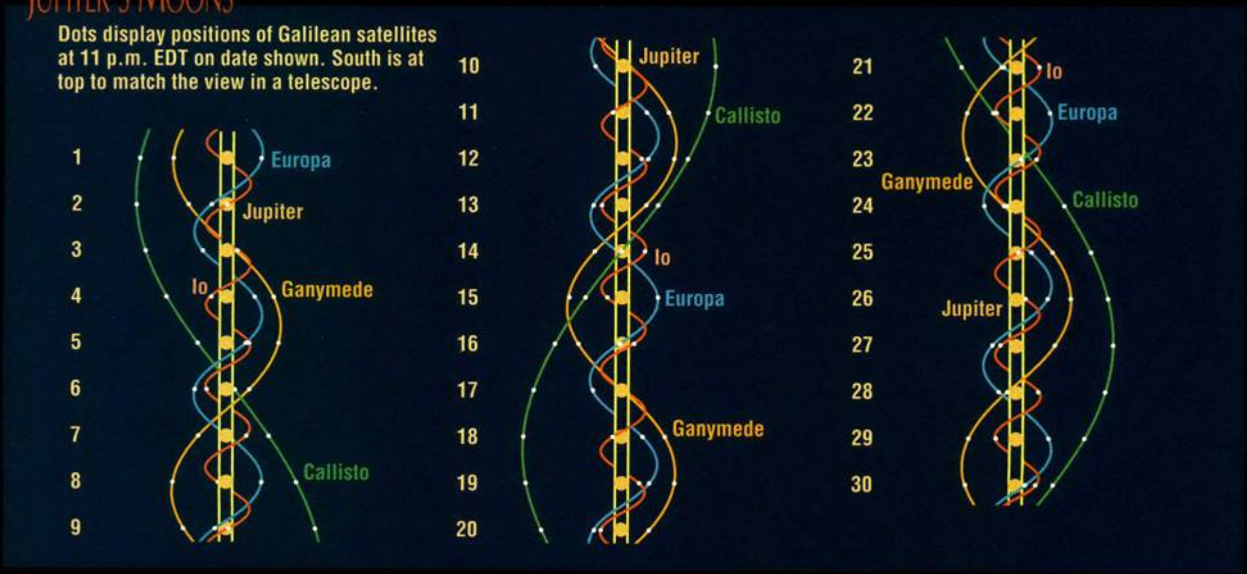
10"

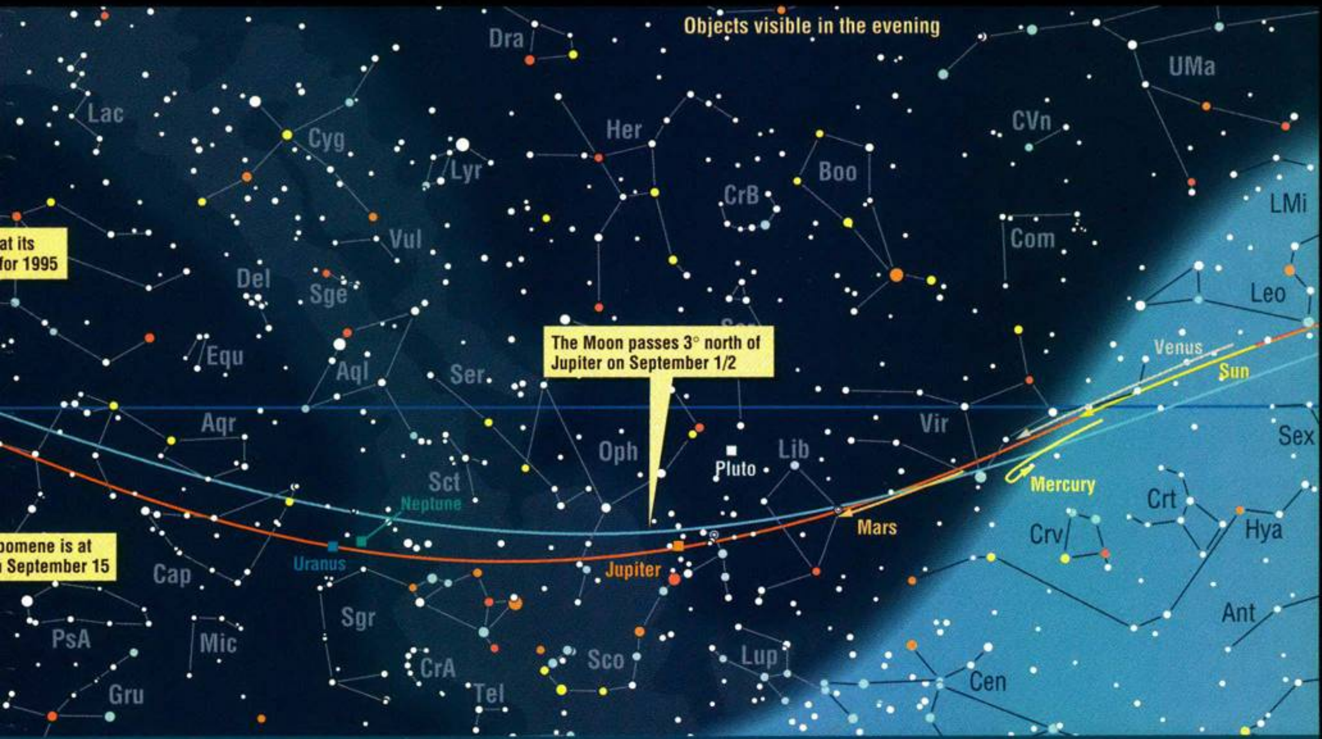
S
W — E
N

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	September 1	September 15	September 30	September 15	September 15
Magnitude	0.1	0.4	–3.9	1.4	–2.0
Angular Size	6.3"	7.8"	9.9"	4.5"	36.2"
Illumination	67%	45%	98%	95%	99%
Distance (AU) from Earth	1.071	0.862	1.681	2.084	5.449
Distance (AU) from Sun	0.466	0.445	0.723	1.520	5.306
Right Ascension (2000.0)	12h12.0m	13h00.1m	13h05.1m	14h11.2m	16h26.6m
Declination (2000.0)	–2°43'	–9°58'	–5°49'	–13°32'	–21°14'

JUPITER'S MOONS


Dots display positions of Galilean satellites at 11 p.m. EDT on date shown. South is at top to match the view in a telescope.


Objects visible in the evening
Dra
UMa
Lac
Cyg
Lyr
Her
CVn
Boo
CrB
LMi
Vul
Com
Del
Sge
Leo
Equ
Aql
Ser
Venus
Sun
Aqr
Vir
Sex
Oph
Pluto
Lib
Sct
Neptune
Mercury
Crt
Mars
Crv
Hya
Uranus
Cap
Jupiter
Sgr
Ant
PsA
Mic
Sco
Lup
CrA
Cen
Gru
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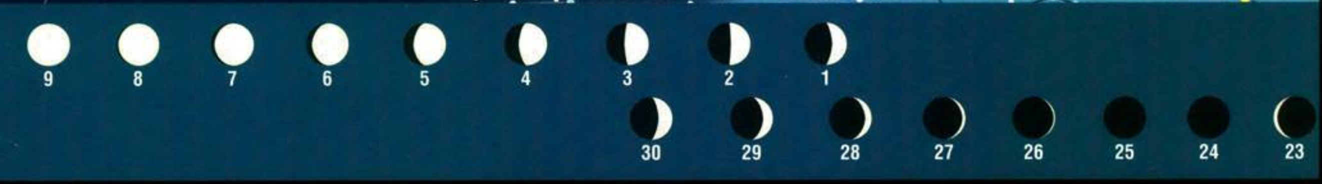
at its
for 1995

The Moon passes 3° north of Jupiter on September 1/2

pomene is at
September 15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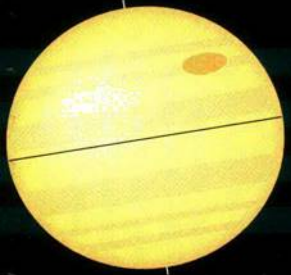
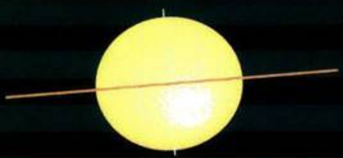
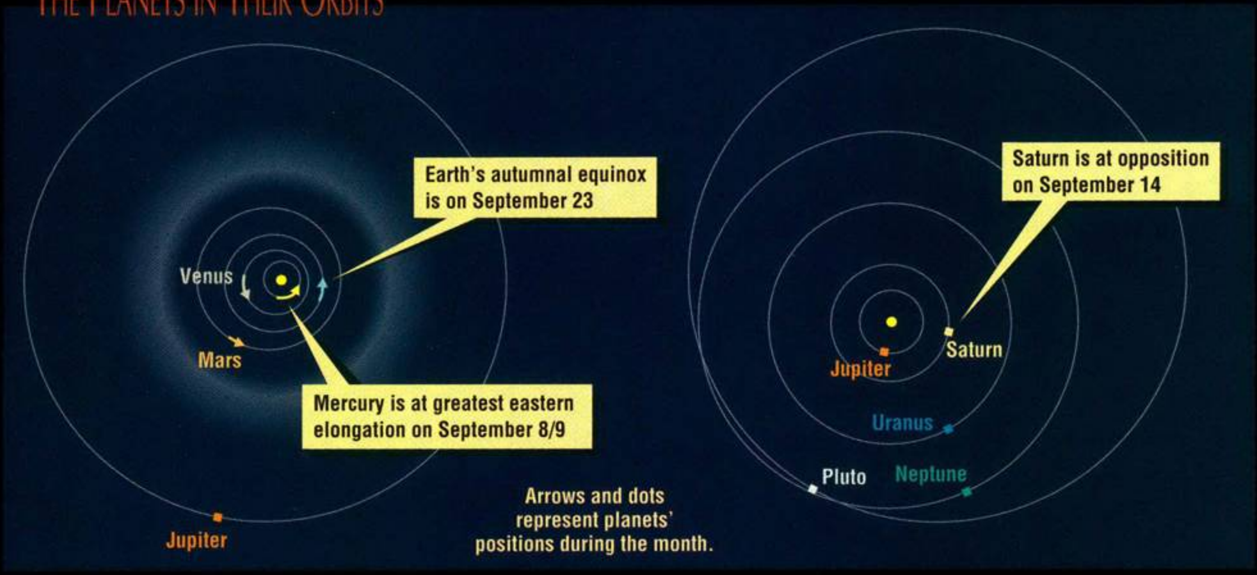




SATURN	URANUS	NEPTUNE	PLUTO
September 15	September 15	September 15	September 15
0.7	5.7	7.9	13.8
19.3"	3.7"	2.3"	0.1"
100%	100%	100%	100%
8.604	19.136	29.635	30.233
9.609	19.730	30.168	29.857
23h32.0m	19h55.7m	19h38.7m	15h55.8m
–5°35'	–21°21'	–20°58'	–6°55'

THE PLANETS IN THEIR ORBITS


Venus
Mars
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Earth's autumnal equinox is on September 23

Mercury is at greatest eastern elongation on September 8/9

Saturn is at opposition on September 14

Arrows and dots represent planets' positions during the month.

for the weeks around ring-plane passage.

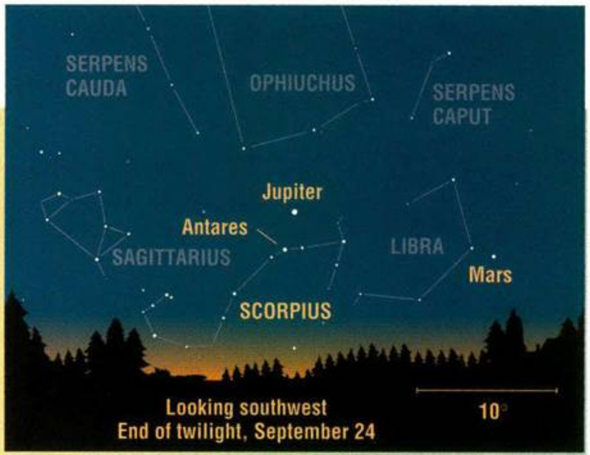
Ring-plane passages come in groups of one to three over about a year's time (see "The Vanishing Rings of Saturn," June 1995). In May, we crossed from the ring system's north face to their south face. For a few months after that, we were looking toward the side of Saturn's rings unilluminated by sunlight. Last month, due to the locations of Earth and Saturn in orbit, the sunlit north face of the rings again came into view. This month the rings are still so nearly edge-on that they look like a razor thin line across the planet.

In November, Saturn's ring plane will intersect the Sun, after which sunlight begins to fall directly on the south face of the rings for the first time in 15 years. We pass through the plane of the rings for the third and last time in this century in February 1996. Then we will be looking at the rings' south face, the face illuminated directly by sunlight.

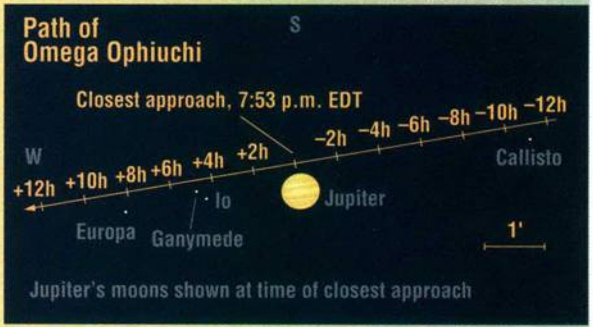
Normally the next most obvious item near Saturn is its bright, cloud-covered moon, Titan. But now that the rings are out of the way, you might also glimpse Tethys, Dione, Rhea, and Iapetus through your small telescope (see "The Dance of the Saturnian Satellites," page 72). These moons orbit close to the plane of Saturn's equator, just as the rings do. When Saturn is tilted with respect to us, the moons appear scattered irregularly around the planet. Now, as we pass through the plane of the planet's equator, the moons appear strung out in a line, much like the moons of Jupiter. They may be visible along the line of the rings, as astronomer James Muirden has said, "threading their way along the sliver of light, like pearls on a wire."

The next planet on our nine-planet quest, **Mercury**, threads along an extremely low path in the west after sunset. The prospects of your viewing it are not favorable. Greatest elongation comes on September 8/9, when Mercury lies 27° east of the

Jupiter Meets Omega Ophiuchi



Looking southwest
End of twilight, September 24



Jupiter's moons shown at time of closest approach

Every now and then a bright planet passes near or in front of a star. For a brief moment we can actually *see* a planet move in its orbit around the Sun. The star appears to close in on and pass a seemingly fixed planet.

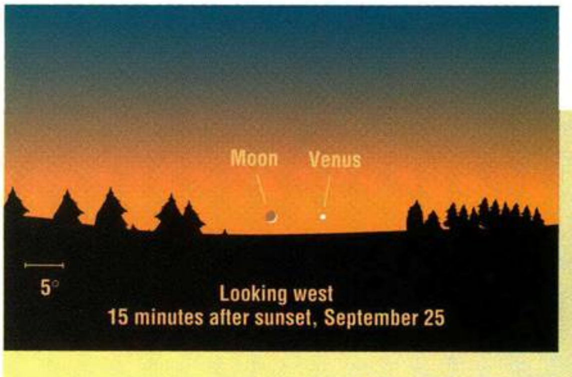
On the evening of September 24, people living in eastern North America south of a line that connects Labrador to the southern shore of James Bay see magnitude 4.5 Omega Ophiuchi approach and pass about an arcsecond south of Jupiter. For about 12 hours either side of closest approach, Omega will look like a fifth bright satellite of Jupiter. The star actually lies 108 light-years from Earth, more than a million times beyond Jupiter.

Even though most of North America lies south of Jupiter's shadow, Omega passes so close, and the planet's limb is so ill-defined, that the star's brightness might lose about a quarter of its brightness. Those north of the shadow line will see Omega flicker erratically as its light shines through the Jovian upper atmosphere. Mideclipse, and Omega's closest approach for the rest of the Americas, is at 7:53 p.m. EDT (23h53m UT).

East coast observers have front-row seats as Omega closes in on and passes south of Jupiter during twilight. Between 4 and 6 hours later, those in the midwest and mountain areas will witness it moving south of Io, Ganymede, and Europa. About 12 hours after closest approach, the star clears the Jovian system altogether.

Incidentally, at 16h05m UT (12:05 p.m. EDT) the Middle East, southwestern Russia, and Ukraine narrowly miss seeing Omega get covered by Callisto. — *J. S.*

Venus Emerges Into Evening



Looking west
15 minutes after sunset, September 25

September opens with Venus emerging slowly but surely from its August 20 passage behind the Sun. Venus hovers low above the western horizon al month, seemingly following the sunset point as it, too, moves south for the northern fall and winter.

Because the ecliptic, the apparent path against the stars the Sun and planets appear to follow, is so shallow to our western horizon this time of year, Venus never strays far from sunset's evening glare. From this low vantage point, the planet remains a brilliant evening star for the rest of 1995.

Finding the "evening star" is a challenge, because during September it sets no more than 20 minutes after the Sun.

Your best chance comes on September 25, when a tiny crescent Moon about one day old lies to the left of Venus. Try spotting the pair during heavy twilight low in the west immediately after sunset.

Binoculars and an unobstructed horizon will help your search. — *J. S.*

A Different Opposition for Saturn

This year's opposition of Saturn is different than any other over the past 15 years. On opposition evening, September 14, the Ringed Planet is two-thirds of the way through a series of ring "disappearances," the previous being August 10, and the next coming on February 11. On those dates the viewing geometry between Earth and Saturn make the one-mile-thick rings appear edge-on and seemingly vanish for Earthbound observers.

All through September, the rings are recovering from last month's vanishing, tipped only slightly to our line of sight. This narrow perspective is even apparent to the naked-eye observer; at magnitude 0.7, Saturn is almost a magnitude dimmer than when the rings are fully open.

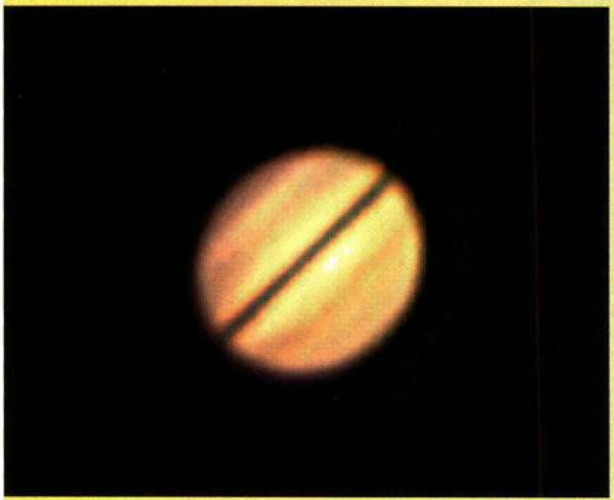
Although Saturn may lack its normally resplendent ring system this year, it does offer much to telescopic observers. Subtleties lost in the distracting glare of nearby rings become more noticeable, such as a plethora of atmospheric detail and the comings and goings of Saturn's faint network of moons.

To help you track the motions of these satellites, take a look at the diagram on the right that shows their relative positions during September.

Parallel lines running through the center of the diagram show Saturn and its narrow rings. Wavy lines that straddle the planet and its rings trace the positions of Tethys (magnitude 10.3), Dione (10.4), Rhea (9.7), and Titan (8.4).

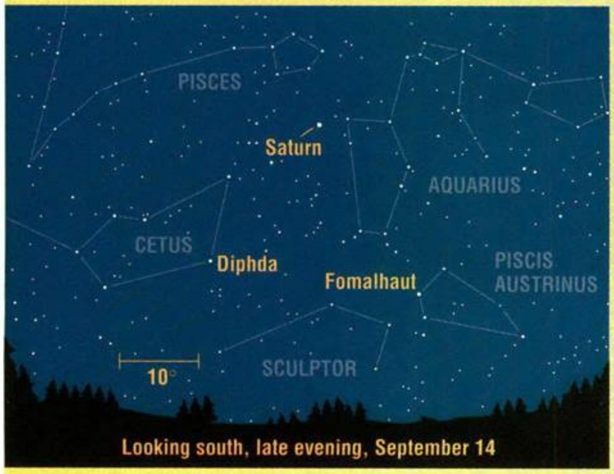
Dots along these lines display moon locations at 11 p.m. EDT. South is at the top to match the view in a telescope. Tethys completes one orbit in just under two days, while Titan takes close to 16 days.

Saturn's moons and ring system look down upon an atmosphere every bit as active as Jupiter's, except a high-altitude haze on Saturn mutes most features. Careful scrutiny reveals a series of dark belts and light zones that mark, respectively, zones of falling and rising gas. Every now and then a white storm appears on the planet's equator, marking where very high clouds of ammonia ice crystals get caught up and sheared by Saturn's 1,100-mile-an hour equatorial jet stream. — *J. S.*



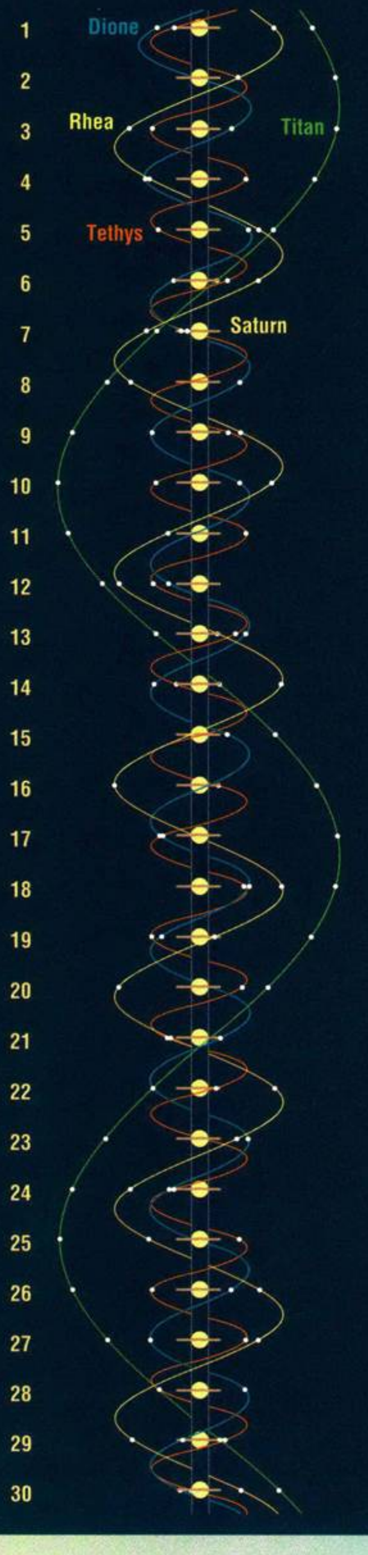
Donald Parker

SPOT THE HIDDEN RINGS in this image snapped a week before the first ring-plane crossing on May 24. Saturn's rings have been getting wider since our second ring-plane crossing on August 10 and continue to broaden throughout September. Take advantage of their thinness to glimpse some of Saturn's faint, inner moons, normally overwhelmed by the rings' intense glare.

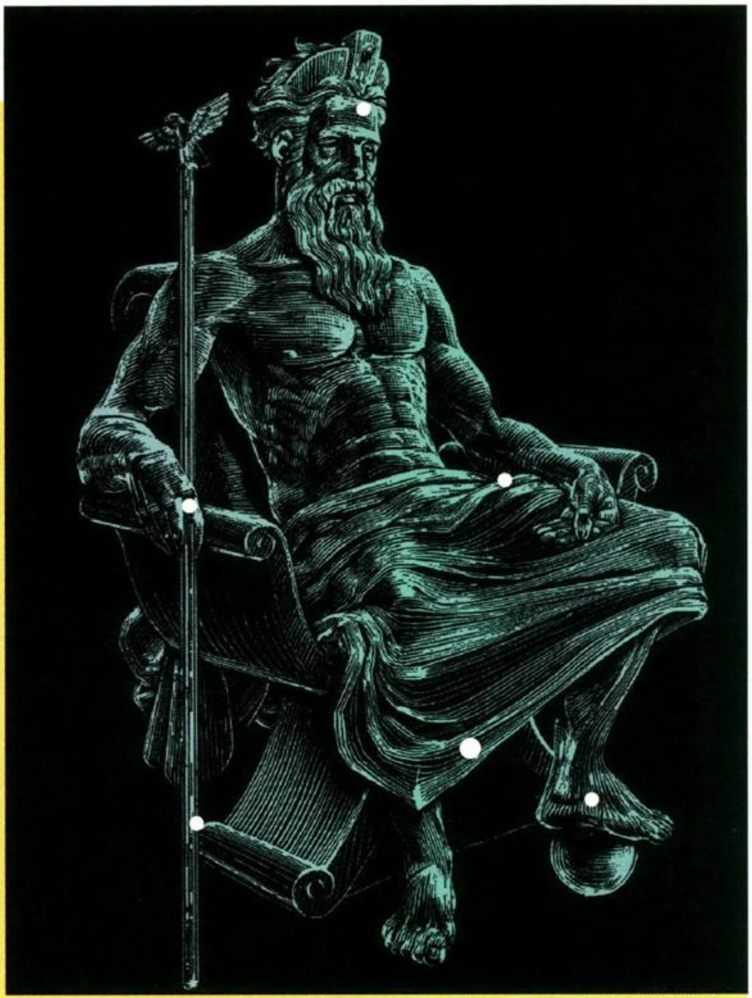


Looking south, late evening, September 14

Dots display positions of Saturn's brightest satellites at 11 p.m. EDT on the date shown. South is at the top to match the view through a telescope.



The Starry Sky:
Cepheus


Keith Ward

Cepheus the King is one of the faintest constellations, but this pattern of stars figures in one of the sky's most ancient and intricate myths. Cepheus was said to be a king of Ethiopia. He was married to the vain Queen Cassiopeia, who claimed to be more beautiful than the sea nymphs. As punishment for Cassiopeia's vanity, the lovely Princess Andromeda — daughter in this royal family of the sky — was tied to a rock by the sea. The story continues to include the Flying Horse Pegasus, Cetus the Whale, and Perseus the Hero.

Although it is faint, Cepheus has a recognizable shape to us in modern times. It resembles a child's drawing of a house. As a circumpolar constellation, Cepheus is visible from the northern United States all night throughout the year. It is at its highest above the northern horizon during the evening hours this month.

The brightest star in Cepheus is Alderamin. It shines at magnitude 2.4 from 48 light-years away. A much more famous object in Cepheus is the star Delta Cephei, located 1,200 light-years away. This is a 4th-magnitude variable star, located 9° from Alderamin. This star was the first of its class to be discovered; now all other stars like it are called "Cepheids."

Cepheid variable stars are a necessary link in the line of reasoning used by astronomers to determine distances in the universe. For stars relatively near Earth, astronomers measure distances with a technique called "trigonometric parallax." As Earth moves from one side of its orbit to the other every six months, nearby stars appear to shift against the background of more distant stars. Careful measurement of this shift gives precise distances, but only works for stars within a few tens of light-years of Earth.

Nearly all objects in the universe are vastly farther away than that. The distances to all the other stars and galaxies in the universe might have been forever unknown, if not for Cepheid variable stars, which vary in brightness in an extremely regular way. The brightness of Delta Cephei, for example, ranges between magnitudes 3.4 and 4.3 over a period of 5 days, 8 hours, and 48 minutes. Some stars vary because they have a companion that passes in front of them, blocking their light. The Cepheids, on the other hand, vary as they swell and shrink in size.

In this century, astronomers discovered a correlation between the rate at which a Cepheid varies in brightness and the star's actual or intrinsic brightness. Thus, wherever Cepheid variables are seen in space, they serve as distance markers. These stars were the first key to knowing for certain that the so-called Andromeda Nebula — a hazy patch in the night sky — is really a galaxy exterior to our Milky Way. Thus, the Cepheids were instrumental in the first stretching of our imaginations beyond our galaxy's boundaries. We have not stopped stretching since. — *Deborah Byrd*

Sun and appears 11° to the lower right of the bright star Spica in the constellation Virgo. At greatest elongation, when the planet shines at magnitude 0.2, try using binoculars to scan for it near the western horizon, half an hour after sunset.

Far fainter but better placed, **Mars** appears as a ruddy object low in the southwest at sunset. It sets about two hours behind the Sun in early September, and about an hour and a half behind the Sun at month's end. It is now exceedingly remote from us at about 17 light-minutes away, or 186 million miles. It shines in a lackluster way, at magnitude 1.4, and appears as a 4.5"-diameter disk in a telescope.

Yet Mars is not without interest now. This is a time for watching the planet move with respect to the stars. Mars had a conjunction with Spica, the brightest star in Virgo, in late August. As the month begins Spica is still near Mars. In September, watch Spica shift into the sunset glare, while Mars lingers above it. As if bidding Spica good-bye, the Red Planet crosses from Virgo into Libra. There the 3rd-magnitude star near it in late September is Alpha Librae, otherwise known as Zubenelgenubi. Be sure to look in the west after sunset on September 27, when Mars appears in the twilight near Zubenelgenubi and a slim crescent Moon.

Just to the east of all these happenings is bright, white **Jupiter**. It sets shortly before midnight when the month begins and in late evening by the month's end. Jupiter is now falling farther behind Earth in its race around the Sun. At magnitude –2.0, Jupiter has faded just over half a magnitude since its June 1 opposition.

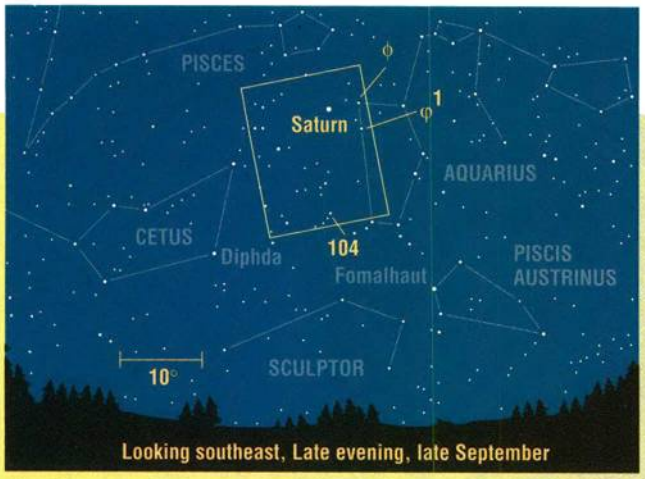
Following the Muse of Tragedy

Winging its way south of Saturn in eastern Aquarius during this month is 18 Melpomene, an asteroid that reaches opposition on the night of September 15. At that time it glows at magnitude 7.8, well within the range of even the most modest of backyard scopes.

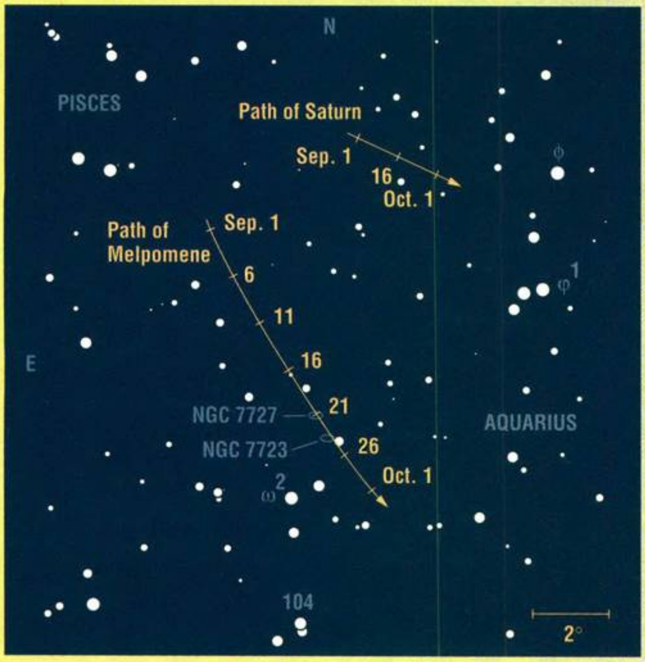
Melpomene was the 18th asteroid discovered, first gleaned in London by British astronomer J. R. Hind on June 25, 1852. But it was the noted Astronomer Royal George Airy who named the asteroid after the Greek muse of sadness and tragedy. The day before its discovery, Airy lost his only daughter in a tragic accident.

Under happier circumstances, we watch this 90-mile-wide chunk of iron and nickel as it moves in its 3½-year orbit around the Sun. On the evening of September 21, Melpomene passes through the arms of the magnitude 11 spiral galaxy NGC 7727. Two days later it passes just west of NGC 7723, another 11th-magnitude spiral galaxy.

Look for Melpomene among the stars of southern Aquarius, just south of moderately bright Saturn (see the top diagram). The bottom field diagram shows Melpomene's movement to the southwest during the month of September into early October. —*J. S.*



Looking southeast, Late evening, late September



Coordinates for 18 Melpomene (11 p.m. EDT)

Date	R.A. (2000)	Dec.	Mag.
Sept. 1	23h51.0m	–7°32.2'	8.0
Sept. 6	23h48.7m	–8°44.9'	7.9
Sept. 11	23h45.9m	–9°58.6'	7.8
Sept. 16	23h42.9m	–11°11.1'	7.8
Sept. 21	23h39.8m	–12°19.9'	7.9
Sept. 26	23h36.8m	–13°22.7'	8.0
Oct. 1	23h34.1m	–14°17.6'	8.1

The Moon, a Double, and the Red Planet

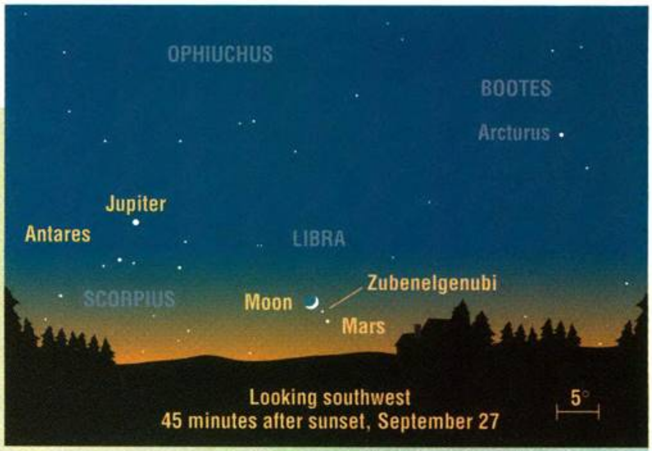
The evening of September 27 brings a special treat for naked-eye and binocular observers. That's when the waxing crescent Moon groups with the beautiful double star Alpha (α) Librae and the red planet Mars.

The trio look completely different from one another.

Our Moon has only a tiny sliver of its surface bathed in full sunlight, while most of it still soaks in Earthshine, sunlight reflected off our planet's oceans and clouds onto the Moon's unlit portion.

Alpha Librae, also called Zubenelgenubi (Arabic for "the northern claw," for Libra once represented the claws of Scorpius), is a multiple star system 65 light-years away. Alpha's 2.8-magnitude, blue-white primary star has a white, magnitude 5.2 companion about 4' to the west. Both are easy targets for small telescopes or binoculars.

Rounding out the scene is ruddy Mars, some 198 million miles away. With a diameter of about 4", don't expect to see much of Mars in binoculars; a small telescope might show the Red Planet as a tiny gibbous disk. That evening, light takes 18 minutes to reach your eyes from Mars. Our closer Moon is only 1.2 light-seconds away. —*J. S.*



Looking southwest
45 minutes after sunset, September 27

Still, Jupiter is far brighter than any star in the sky, and it is impossible to mistake. The giant planet is near the Moon twice this month, first on September 1 and again on September 29. The bright star near Jupiter this month is Antares in the constellation Scorpius. Jupiter is 5° north of the scorpion's heart on September 20. A telescope turned to Jupiter reveals its dusky cloud bands and four large moons.

To the north, and at the other end of the brightness scale, is **Pluto**, which lingers at magnitude 13.8. It sets around midnight as the month opens and a couple of hours earlier by month's end. This tiny world, which will become the outermost planet again in 1999, requires at least an 8-inch telescope to be seen.

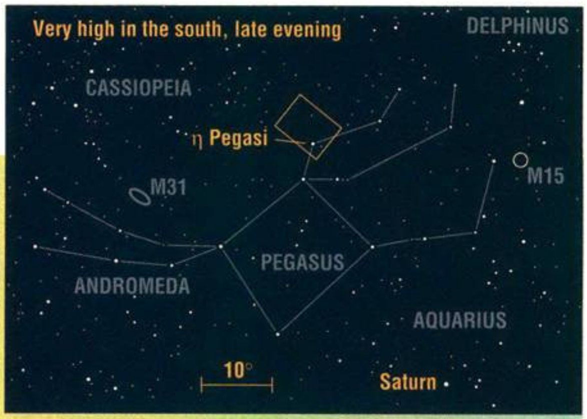
Rounding out the evening planets are **Uranus** and **Neptune**, low in the southeast after sunset. Uranus shines at magnitude 5.7 and crosses back into Sagittarius this month. Neptune shines at magnitude 7.9 within the borders of Sagittarius.

At the month's end, if you look carefully (binoculars will help) you might glimpse still another evening planet that is exceedingly low in the west after sunset. It is **Venus**, the brightest planet, which passed behind the Sun last month as seen from Earth.

Venus is now returning to the evening sky. Although it is very near the horizon, you may be able to see it shining through the trees. At magnitude –3.9, only the Moon and Sun are brighter in our skies. At the end of September, Venus sets half an hour after sunset as seen from 40° north latitude. Those at southerly latitudes have only a slightly better chance to see it. Still, if your sky is free of clouds and your horizon unencumbered by trees or buildings, look for Venus. Its brilliant light will seem to pierce the bright evening twilight. ☐

Deborah Byrd writes and produces the daily "Earth and Sky" radio series.

Observer's Challenge:
Chasing Down Stephan's Quintet

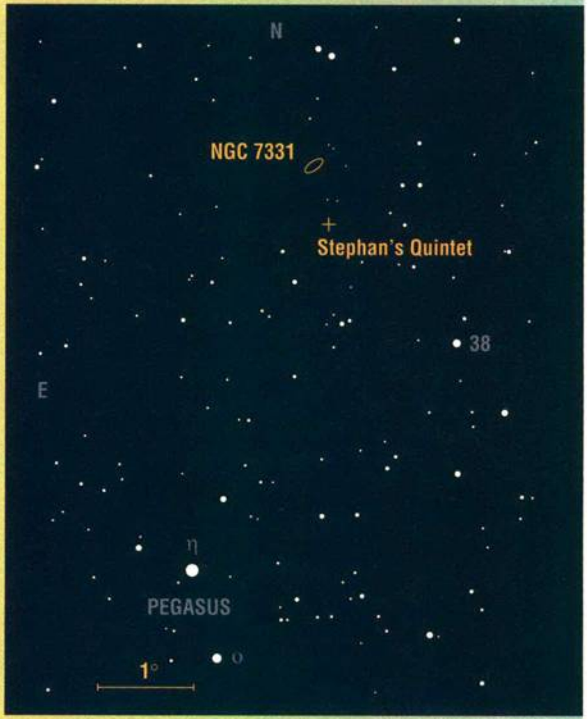


In the annals of autumn galaxy hunting, there's one tight grouping of galaxies that stands out in any self-respecting deep-sky aficionado's mind: Stephan's Quintet. What makes this cluster so appealing is the variety of orientation and brightness its five members provide.

Within a space of 10' lie NGC 7320, a 12.7-magnitude spiral, and no less than four other galaxies: 13.6-magnitude elliptical NGC 7317, magnitude 13.2 elliptical NGC 7318A, and barred spirals NGC 7318B and NGC 7319, both magnitude 13.1.

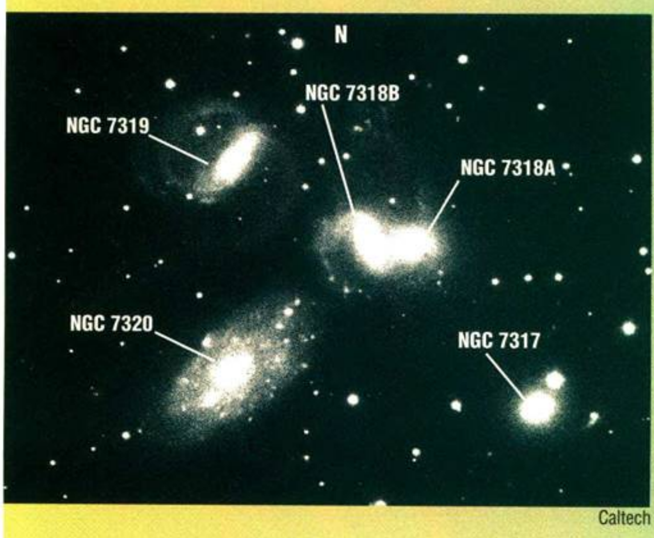
Although the five galaxies look intertwined in long-exposure photos, the brightest and easiest one to spot, NGC 7320, is actually seven times closer than the other four, which lie about 293 million light-years distant.

To find the group, start by locating the 3rd-magnitude star Eta (η) Pegasi off the northwestern corner of the Great Square of Pegasus. Now move 4.3° north of Eta to find a 10th-magnitude spiral galaxy called NGC 7331, a worthwhile target in itself. Just ½° southwest of NGC 7331 lies Stephan's Quintet, named for the astronomer M. E. Stephan, who first glimpsed them in 1877.



Southernmost member NGC 7320 looks like a bright oval in telescopes with apertures of between 6 and 10 inches. The other galaxies need scopes of at least 12 inches to yield any detail.

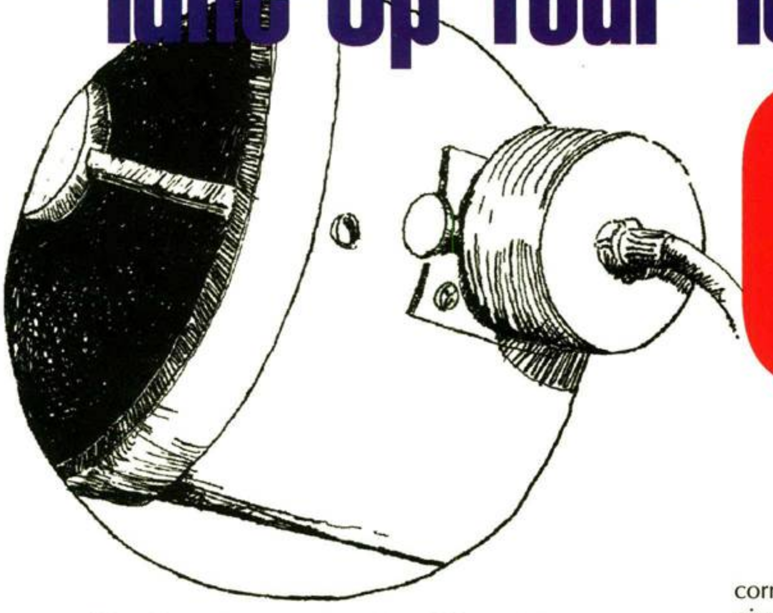
In a 13.1-inch, NGC 7320 has a face-on spiral appearance, with nearby NGCs 7318A&B forming what appears to be a "double galaxy" that's difficult to split unless the night is especially transparent and steady. To the north, NGC 7319 looks like an edge-on spiral, while the cluster's westernmost member, starlike NGC 7317, pairs with a faint field star.



Caltech

For observers with telescope apertures greater than 16 inches, the view approaches that seen in the photo. If you are using a scope of this size, detour back to NGC 7331 and check its retinue of six companions. Higher eyepiece magnifications will darken the sky and increase contrast. — *J. S.*

Tune Up Your Telescope for CCD



by
Greg Terrance and
Ray Ciccariello

The key to successful CCD picture-taking lies in making the telescope perform like a champ. Here's a nine-step checklist to turn that small scope into a backyard giant.

How often have you paged through ASTRONOMY, drooled over the color CCD images of galaxies, and dreamed of duplicating them with your own imaging rig? As the eyes slide down to the technical data, the heart sinks: a 25-inch telescope. Fleetingly, you consider plundering the kids' college fund before abandoning the whole idea of going CCD.

Fear not, brave imagers of the night sky. You needn't buy a behemoth telescope to enter the world of CCD imaging and produce some pretty snappy and impressive images. Most of these tips will help conventional astrophoto systems, too.

The images in this article were created with an 8-inch reflector and an 8-inch refractor. The techniques that follow, however, work with any type of optical design including reflectors, refractors, and compound telescopes like Schmidt-Cassegrains. Our experiments with CCD imaging have employed various cameras, including a Lynxx PC, SBIG ST-5, and SBIG ST-6. Whichever telescope design and CCD camera you use, you'll need the basic astrophoto setup: focuser, sturdy mount, right ascension drive, drive corrector, and accessories. This nine-step program will take it from there.

Step 1: Beef Up the Mount

To counter the motion of stars across the sky during exposures, a mount must have a right ascension clock drive and, at a minimum, an adjustable slow-motion control on the declination axis. In locating an object and during an exposure you'll need to make minor corrections in the telescope's tracking to ensure sharp, pinpoint images. Moving the telescope tube by hand does not work well because of the fine adjustments needed. The fine motions of an electric declination drive will make recentering easy and efficient. This is especially important for planetary imaging and for closeup shots of small deep-sky objects.

With telescope mountings, the law of the land is overkill. With a refractor or reflector, get the mount intended for the next larger size telescope. If you have a Schmidt-Cassegrain, purchase the manufacturer's heavy-duty model, or at least their heavy-duty wedge. If you have a permanent mount or pier, fill it with concrete or dry sand to deaden vibrations (see "Improving Your Mount," December 1994).

Step 2: Adjust the Right Ascension Drive

First, during the daytime, adjust the right ascension worm gear so that it has a small amount of backlash and no binding (see the owner's manual). Check the adjustment by removing the right ascension motor and turning the right ascension drive gear by hand. You'll feel binding if it occurs and the amount of backlash within the gear system.

Now set your mount's drive corrector at the proper rate of speed to match the object that you are imaging, whether it be lunar, planetary, or deep-sky. Along with polar alignment (see step 5), this adjustment increases the time that you can expose without tracking errors and reduces the need to constantly re-center lunar and planetary objects in the field of view. Planetary images often nearly fill a CCD's field of view so the benefit of a well-tuned drive corrector is a big one.

Step 3: Get a Smooth Focuser

Compared to an average eyepiece or 35mm camera, the amount of sky covered by a CCD camera is very small. Because of this, it's relatively difficult to center and keep an object where you want in a CCD frame. Although this isn't a major problem for visual observing, any shifting or wobbling by your focuser will cause big problems with CCD imaging. Many

The Horsehead Nebula

8-inch f/5 reflector

focusers are so unstable that an image will hop out of the CCD's field as you change the scope's focus. The problem is bad enough with deep-sky imaging, which uses the widest field of view possible, but if you plan on doing planetary imaging, which employs greater magnification and nets a smaller field, a solidly built focuser is even more critical.

Check your focuser during a typical night under the stars at low and high magnifications. Your scope's focuser should display no image shift as you rack it in and out, especially if you want to image planets. It should have the ability to make fine focusing adjustments smoothly. It should hold the weight of your CCD camera without flexing. It should provide the ability to maintain sharp focus by locking in place exactly where you want it.

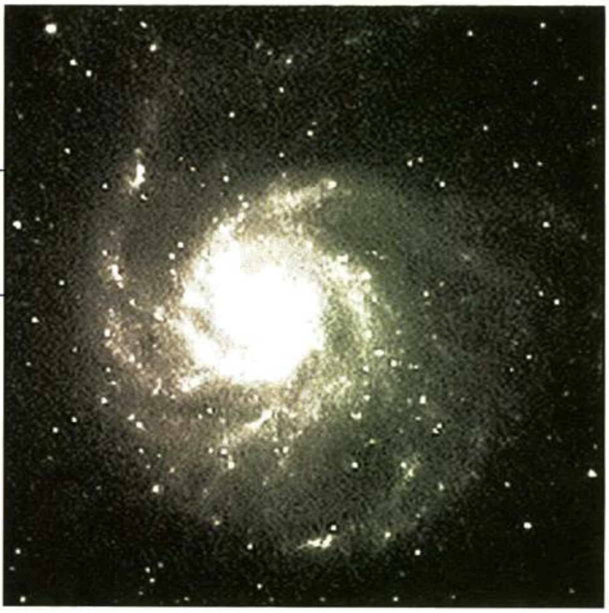
If not, you need to upgrade. Consult the ads in Astronomy to find a variety of companies that offer high-quality replacement focusers for every telescope design. If you already have a good manual focuser, consider adding an electric focuser. This not only minimizes telescope vibrations but allows changing focus to a finer degree than can be achieved by hand.

Step 4: Balance the Mount

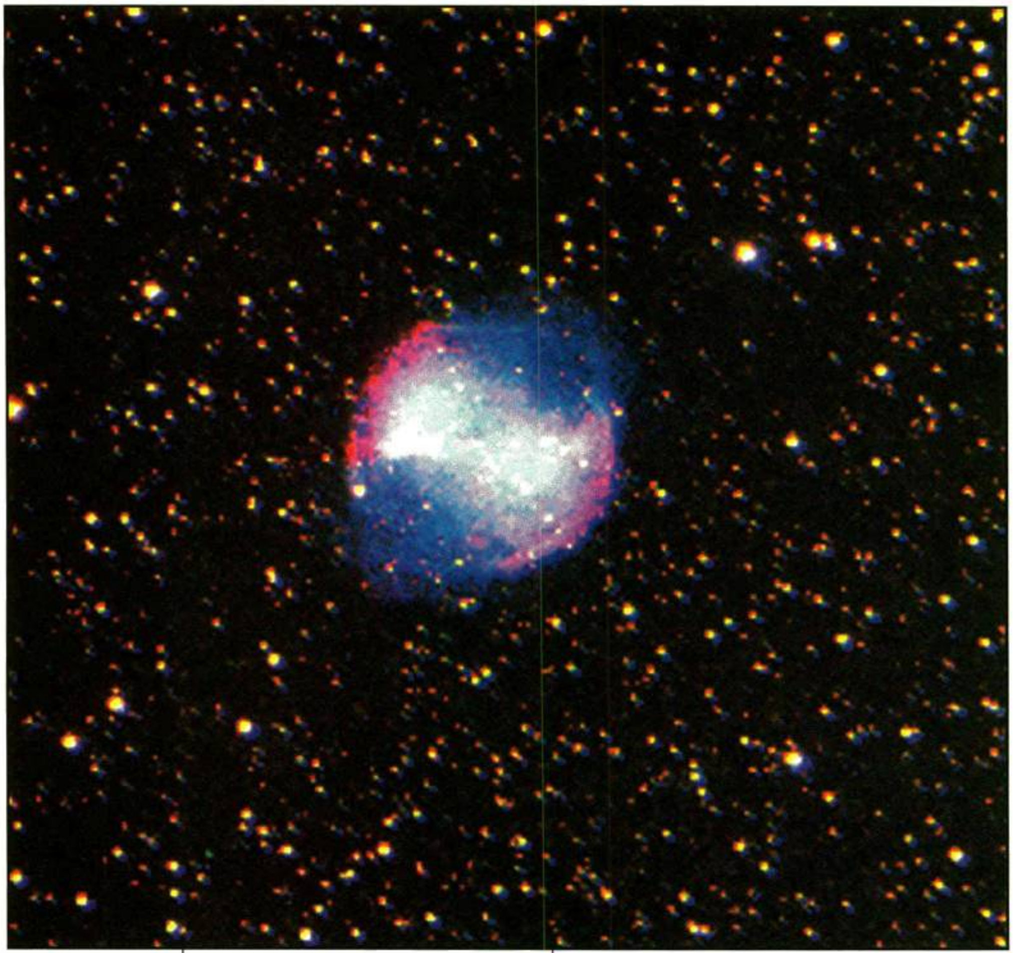
Your mount should balance in three planes: horizontal, vertical, and right ascension. Balancing the

Galaxy M101

8-inch f/5 reflector

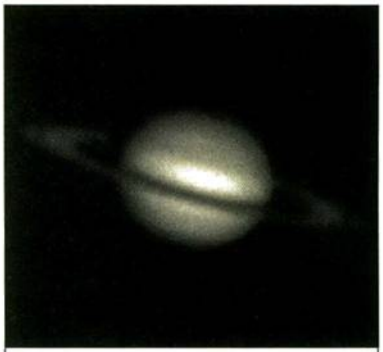


All images in this article were taken by Gregory Terrance using either an 8-inch f/5 reflector or an 8-inch f/9 refractor optimized with the techniques described. Terrance used an SBIG ST-6 or an SBIG ST-5 CCD camera for the deep-sky images and a SpectraSource Lynxx PC CCD camera for the planetary images.



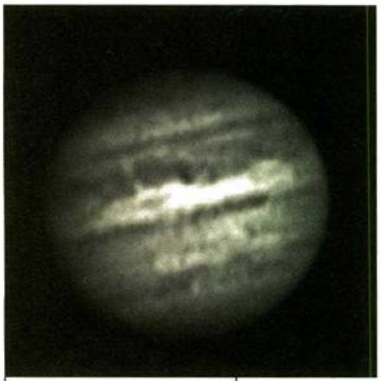
The Dumbbell Nebula

8-inch f/5 reflector



Saturn and White Spot

8-inch f/9 refractor



Jupiter

8-inch f/5 reflector

mount requires a proper sequence of actions. Two steps balance the weight of the tube itself and a third balances the scope with a counterweight so the clock drive motor can turn the scope easily in right ascension.

First, balance the mount while the tube is horizontal. The two ends of the scope must have an equal weight distribution. Next, balance the mount while the tube is vertical. Accessories offset on one side of the tube such as finderscopes, CCD cameras, and heavy eyepieces will change the vertical balance. Finally, balance the mount in its right ascension axis. You need to match the counterweight side of the mount with the telescope side.

Because many CCD cameras weigh more than an average eyepiece or 35mm camera, you need to balance the telescope with the CCD camera attached. Doing this will reduce the stress on your mount's right ascension and declination motors. Unless the mount is properly balanced, most drive motors cannot overcome the weight differences encountered when burdened with a CCD camera and may burn out.

Step 5: Polar-Align Precisely

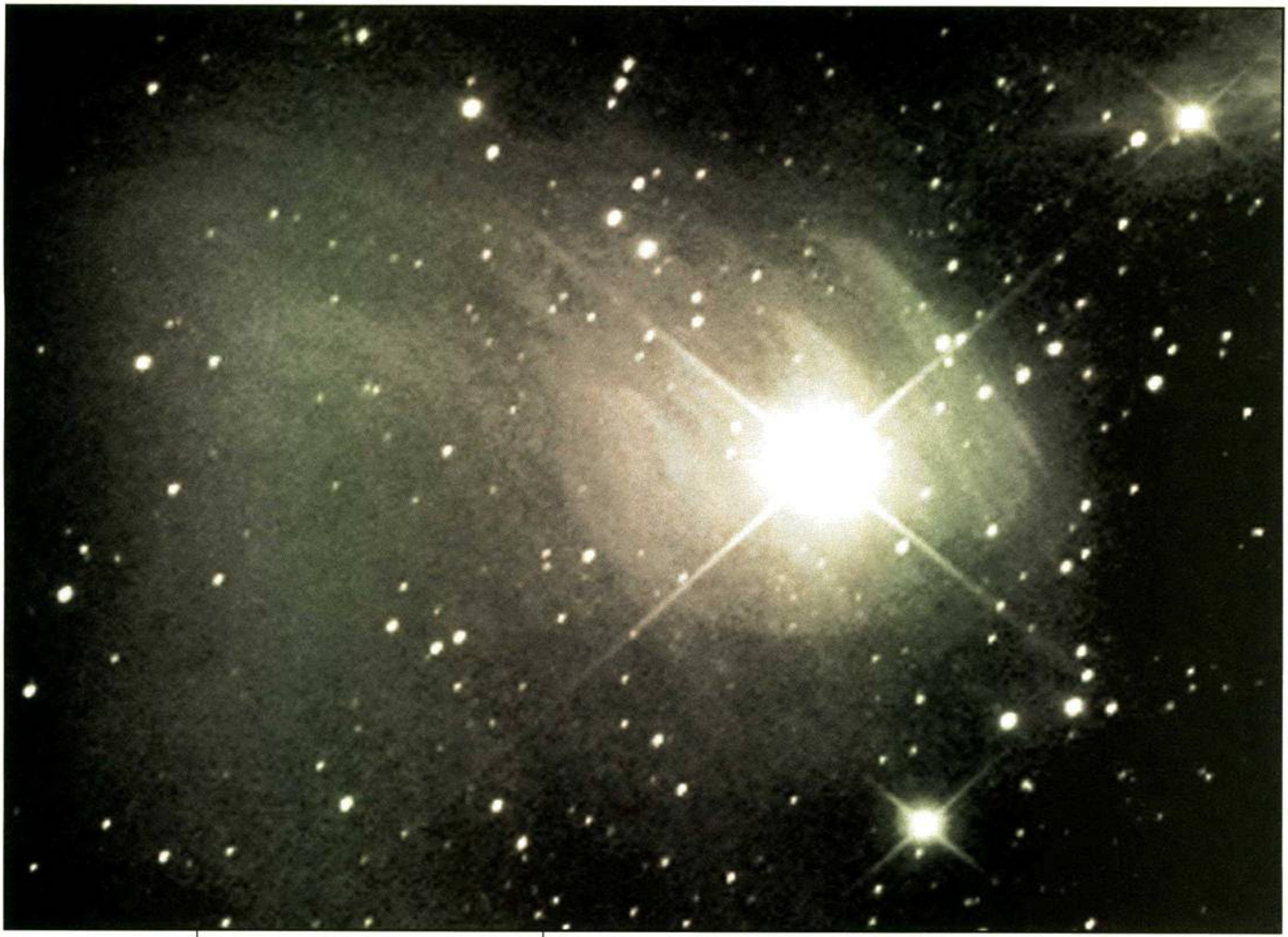
The best CCD images are those made from relatively long exposures, which reduce the image's noise compared to the object's signal. To make long exposures, you need to polar align the telescope's mount. A properly aligned telescope will make searching the sky for targets easier, especially if you have digital setting circles.

For owners of permanently mounted telescopes, we recommend the star drift method of polar aligning. If you have a portable mount that has to be set up each night, purchase a polar alignment scope if one is available for your mount. There are many ways to polar align, so try different methods to see what works best. (See "Polar Aligning Your Telescope," May 1992.)

Step 6: Collimate the Optics

Take the time to learn how to collimate your optics, and go through this process each time you set up to image. A poorly collimated set of optics will scatter light and produce unsatisfactory images. Although Newtonian telescopes require more attention to maintain alignment, all telescopes, including refractors and Schmidt-Cassegrains, will benefit from collimation. We have used the Tectron collimation set and reference manual. Experienced backyard astronomers can use the "star test" method (see "How to Collimate Your Telescope," April 1992).

To get the most from the optics in a Newtonian, make sure the optics are not pinched in their cells, which produces odd-shaped star images. The primary and secondary holders are there to maintain alignment and *prevent the optics from falling out*, but nothing more, so don't clamp the mirror clips onto the mirror's surface. With CCD imaging the secondary holder can be smaller than that required for



The Merope Nebula

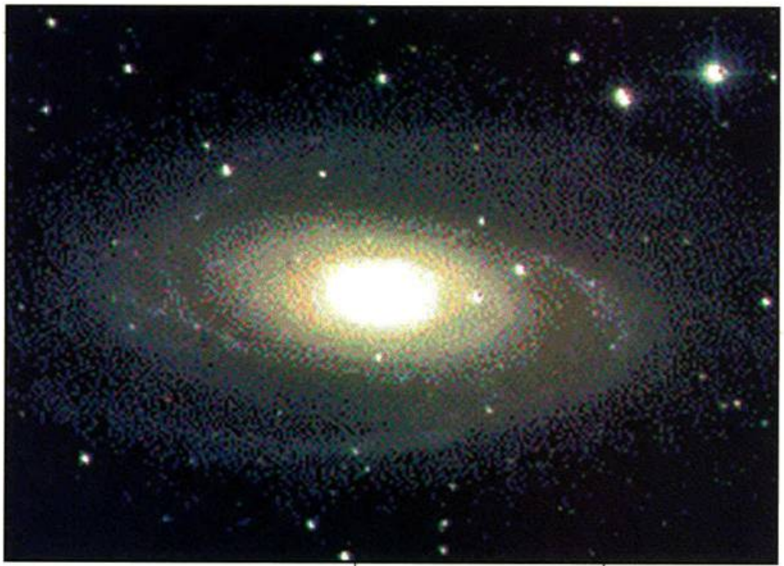
8-inch f/5 reflector

astrophotography with conventional film, because the CCD's field is so small. Because it's less of an obstruction, a smaller secondary mirror improves the contrast of the image, bringing out details.

Step 7: Focus the Camera Critically

Once you're out under the stars and ready to image, you need to focus the image carefully. A CCD camera won't show an out-of-focus star image as easily as an eyepiece or a conventional camera viewfinder. Unfocused star images, which appear like white doughnuts, will not be visible on your computer screen until you are fairly close to focus. This is because a CCD's field of view is small enough that an out-of-focus star often fills the array's field with either the dark center of the doughnut or its white edge. You may be centered directly on a star but so far from focus that you won't see anything.

To prevent this frustrating situation, use one of two methods. In the first, point your telescope at a bright star and center the star in the field of view. Use a guiding eyepiece for the best results. If you know where the focal plane of your telescope is and how much "in travel" your CCD camera needs, attach the camera and set your focuser accordingly. If you don't have this information, begin by racking the focuser all the way in. Set the camera for an exposure of two to five seconds. Move the focuser out about 1/4" after each exposure registers on the monitor. At some point, you'll start to see an out-of-focus star image. Reduce the exposure time as you



Galaxy M81

8-inch f/5 reflector

Galaxy M33

8-inch f/5 reflector

Galaxy NGC 253

8-inch f/5 reflector

approach focus so that the CCD array doesn't overexpose. Continue this process until you reach sharp focus. An electric focuser works best with this approach.

Or you can try this method. Center your telescope on a bright star. Place a piece of translucent tape over the end of your focuser. Focus the star's image on the tape. Subtract the in travel of your CCD camera from the distance that your focuser is racked out. Now you should be close enough to focus so that star images will be visible on your monitor. Make your final focusing adjustments by viewing images on the monitor.

Once you've determined where your telescope and CCD come to focus, take a measurement of how far your focuser is racked out. Record this as a starting point for future imaging sessions. For those who use more than one telescope or plan on imaging planets and deep-sky objects, maintain a logbook of measurements for each setup.

Step 8: Make a CCD-Compatible Eyepiece

To create a universal eyepiece for focusing your CCD camera, take the following steps. Accurately focus the camera and lock the focuser's position. Remove the camera and insert a medium- to high-power eyepiece. Focus on the star by sliding the eyepiece in or out of the focuser barrel (you may need a focuser extension tube). Do not adjust the focuser. When you have the star in focus, use a scribe or a piece of tape to mark the barrel of the eyepiece. From that point on, you'll be able to use this eyepiece to center and focus the CCD camera. The telescope's focuser can stay in the proper position to hold the CCD camera and the eyepiece will also focus sharply at that position.

Step 9: Find Your Target

After focusing, the next step is to locate a target to image on the CCD chip. The larger the CCD array, the easier it is to locate an object. Because of the shorter focal lengths needed for deep-sky imaging, galaxies and nebulae imaged at the telescope's prime focus are easier to locate than planets imaged with eyepiece projection.

To find deep-sky objects, use a low- to medium-power eyepiece to center the galaxy or nebula. If you use the CCD-compatible eyepiece, the object should be close to center when you take a test exposure. Make a final focus adjustment if necessary and recenter the object before beginning an exposure.

With an accurately aligned mount and guidescope, you can often center deep-sky objects with the guidescope alone. In this instance, the focused CCD camera stays mounted on the telescope. Deep-sky objects may also be centered with an accurately aligned mount and digital setting circles.

Planetary imaging is a bit more challenging. Insert a

The Trifid Nebula

8-inch f/5 reflector

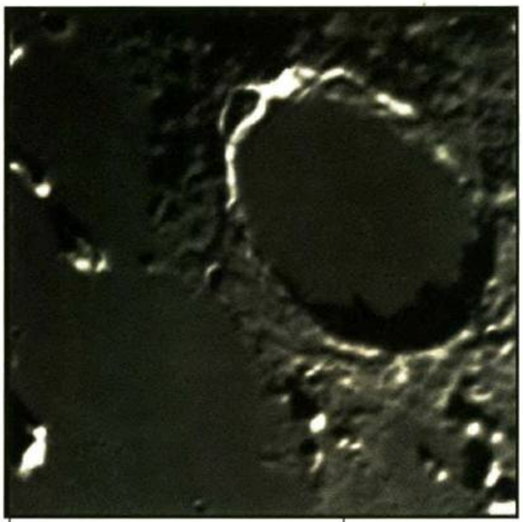
guiding eyepiece into the focuser and center the planet. After attaching the CCD camera at its approximate focus point, take an exposure and view the monitor to see if the planet is indeed there. There's a good chance that, even if you've done everything right, you will not have the planet centered. But you should be close.

Because of the long focal lengths needed for planetary imaging, the image will sometimes drop out of the field. If this happens and nothing is visible, defocus the image slightly and you should be able to see the outer edge of the unfocused planet. Move the scope toward the dark center of the unfocused image and refocus the planet. Do not defocus too much, or the image will be too dim to see.

Move Over, Big Guys...

In the past, small telescopes have never performed very well for capturing planets on film. This was due to the fact that large image scales and long exposures were required to show any detail on film. CCDs have changed this. Small telescopes and CCDs can now capture impressive detail. The best advice for planetary images is to take the time to focus sharply and take lots of images. You can sort out the images ruined by poor seeing at your leisure. Use eyepiece projection and shoot at f/15 to f/30.

In addition to ease of use and low cost, small telescopes have another great advantage over large ones. They provide incredible fields of view. Many deep-sky objects are too large to be captured with a large scope and a CCD. A properly optimized small scope, however, can record vast stretches of big, showpiece objects like the Orion Nebula, the Lagoon Nebula, the Andromeda Galaxy, and many others. Telescopes in the 4- to 8-inch range can easily capture all of the Messier objects and thousands in the *New General Catalogue*. These small, incremental improvements and upgrades will enable your small scope to produce CCD images like the best you've seen published in these pages. □



Lunar Crater Plato

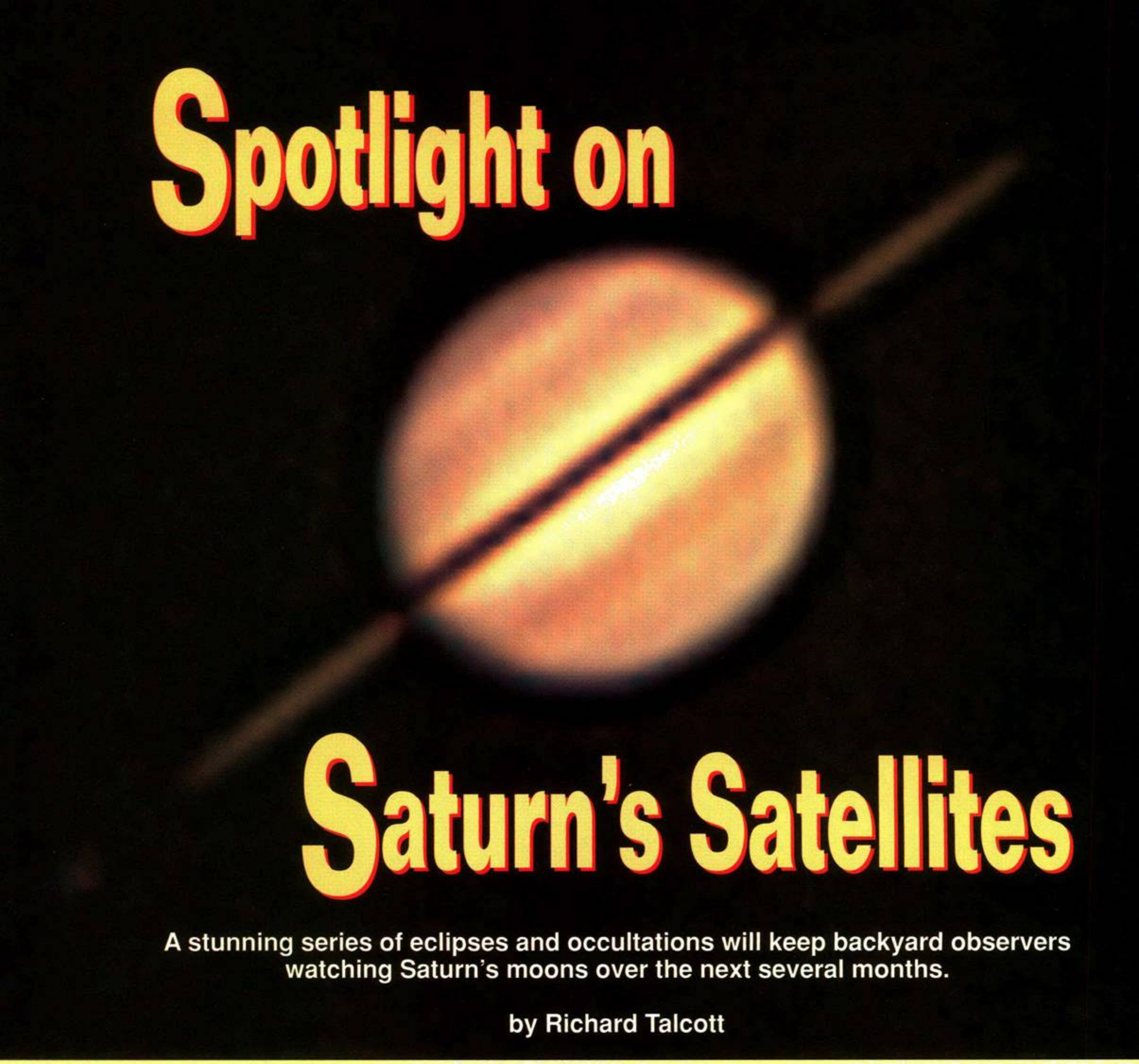
8-inch f/9 refractor

Greg Terrance and Ray Ciccariello work for ITT Automotive in Rochester, New York. They are avid astroimagers, and many of Terrance's images have appeared in ASTRONOMY.

Spotlight on Saturn's Satellites

A stunning series of eclipses and occultations will keep backyard observers watching Saturn's moons over the next several months.

by Richard Talcott



WHEN SATURN'S RINGS TILT nearly edge-on to Earth, so they appear as no more than a thin line, the planet's satellites eclipse and occult one another in a year-long sequence of events. This photo shows Saturn in mid-May, just before the first ring-plane crossing.

A truly spectacular eclipse of the Sun awaits observers on Saturn's moon Rhea on September 24. The Sun's tiny disk will disappear as its sister satellite Tethys passes in front of it. For six minutes Tethys will race across the face of the Sun, leaving just the ghostly corona showing at peak eclipse. The sky will darken enough that several planets will appear, including Jupiter some 30° to the east of the Sun. Even more impressive, however, will be the crescent Saturn, looming 12° across.

Although no one is yet organizing eclipse tours to Saturn, you can view this very same eclipse from the comfort of your own backyard. With a modest-sized telescope, you can watch the shadow of Tethys cover Rhea, dimming that satellite by 47 percent at maximum eclipse at 1h16m UT (9:16 p.m. EDT on the 23rd).

A whole series of such events occurs over the course of several months, as the Sun and Earth lie near the ring-plane of Saturn. Because six of Saturn's seven brightest satellites — Mimas, Enceladus, Tethys, Dione, Rhea, and Titan — lie in nearly the same plane as the rings, one can pass in front of another as seen from Earth, resulting in a mutual occultation. Similarly, one satellite can cast a shadow on another, creating a mutual eclipse. In addition to these mutual events, the satellites also pass into and out of Saturn's much bigger shadow, which eclipses them from view.

EVENTS OF THE SATURNIAN SATELLITES

Date	Begin Time	End Time	Event	Type of Event	Light Loss	Distance
August 2	9h44.4m	9h46.4m	Tethys eclipses Mimas	Partial	65%	3.0
August 4	7h02.2m	7h04.9m	Tethys eclipses Mimas	Partial	61%	3.0
August 5	5h01.5m	5h05.1m	Mimas occults Rhea	Partial	1%	2.9
August 6	4h20.4m	4h23.0m	Tethys eclipses Mimas	Partial	56%	3.0
August 8	1h38.7m	1h41.4m	Tethys eclipses Mimas	Partial	46%	3.0
August 8	5h25.0m	5h26.0m	Dione occults Enceladus	Partial	2%	3.4
August 9	6h40.9m	6h42.5m	Enceladus occults Rhea	Annular	9%	2.5
August 11	10h32.5m	10h34.2m	Rhea occults Enceladus	Partial	5%	3.6
August 12	9h00.0m	9h04.0m	Mimas occults Enceladus	Partial	39%	3.0
August 14	5h11.8m	6h49.6m	Mimas occults Titan	Annular	1%	2.6
August 14	9h09.4m	9h27.2m	Saturn eclipses Titan	Disappearance	—	1.9
August 15	3h02.2m	3h59.6m	Dione occults Titan	Annular	5%	4.5
August 15	7h48.6m	8h28.4m	Dione occults Titan	Partial	4%	6.0
August 16	11h52.0m	11h54.0m	Rhea occults Enceladus	Total	13%	2.8
August 20	10h38.5m	10h39.9m	Mimas occults Dione	Annular	11%	2.2
August 23	5h48.8m	5h50.0m	Mimas occults Rhea	Partial	3%	2.6
August 25	1h47.9m	1h49.2m	Tethys occults Enceladus	Partial	20%	3.0
August 28	10h46.5m	10h47.5m	Enceladus occults Mimas	Partial	12%	2.4
September 1	10h51.2m	10h55.2m	Tethys occults Rhea	Partial	29%	4.6
September 3	7h53.0m	7h56.4m	Tethys occults Dione	Partial	26%	4.7
September 21	3h11.2m	3h17.9m	Dione occults Tethys	Partial	31%	4.9
September 24	1h13.4m	1h19.4m	Tethys eclipses Rhea	Annular	47%	4.9
September 24	5h15.5m	5h17.2m	Mimas eclipses Enceladus	Partial	8%	3.1
October 1	12h02.9m	12h18.4m	Saturn eclipses Titan	Reappearance	—	1.6
October 3	2h57.9m	3h00.9m	Enceladus eclipses Mimas	Partial	51%	3.1
October 7	10h30.5m	10h33.5m	Mimas eclipses Rhea	Partial	5%	3.3
October 9	8h06.4m	8h07.7m	Tethys eclipses Enceladus	Partial	9%	3.6
October 17	11h17.1m	11h32.3m	Saturn eclipses Titan	Reappearance	—	2.1
October 24	10h19.9m	10h21.9m	Tethys eclipses Enceladus	Partial	28%	3.7
October 25	8h25.7m	8h28.7m	Saturn eclipses Rhea	Reappearance	—	1.6
October 29	4h21.9m	4h23.9m	Enceladus eclipses Tethys	Annular	28%	3.0
October 30	2h16.4m	2h19.7m	Tethys eclipses Rhea	Partial	19%	4.2
November 2	10h30.4m	10h45.4m	Saturn eclipses Titan	Reappearance	—	2.5
November 2	22h34.4m	22h36.0m	Tethys eclipses Enceladus	Partial	36%	3.0
November 3	9h21.9m	9h24.9m	Saturn eclipses Rhea	Reappearance	—	1.6
November 7	1h59.5m	2h00.9m	Tethys eclipses Mimas	Partial	5%	2.7
November 7	21h50.0m	21h53.0m	Saturn eclipses Rhea	Reappearance	—	1.7
November 8	23h16.5m	23h18.2m	Tethys eclipses Mimas	Partial	38%	2.7
November 9	7h40.5m	7h42.5m	Dione eclipses Enceladus	Partial	5%	3.8
November 9	21h54.0m	22h08.0m	Titan eclipses Enceladus	Total	100%	3.9
November 10	4h21.0m	4h27.4m	Titan eclipses Mimas	Total	100%	2.0
November 12	1h23.5m	1h26.2m	Dione eclipses Enceladus	Partial	47%	3.8
November 12	10h18.2m	10h21.2m	Saturn eclipses Rhea	Reappearance	—	1.7
November 16	22h46.3m	22h49.3m	Saturn eclipses Rhea	Reappearance	—	1.7
November 17	1h38.7m	1h41.7m	Dione eclipses Rhea	Partial	13%	3.1
November 18	9h42.6m	9h57.6m	Saturn eclipses Titan	Reappearance	—	2.8
November 18	9h42.7m	9h44.7m	Tethys eclipses Mimas	Partial	100%	2.6
November 20	6h33.2m	6h36.5m	Dione eclipses Enceladus	Partial	100%	3.9
November 20	6h59.9m	7h01.9m	Tethys eclipses Mimas	Partial	100%	2.6
November 20	23h53.4m	1h35.0m	Dione eclipses Rhea	Partial	12%	3.5
November 21	9h59.0m	10h00.9m	Saturn eclipses Dione	Reappearance	—	1.5
November 22	4h17.0m	4h19.0m	Tethys eclipses Mimas	Partial	99%	2.6

Begin Time: Universal time at beginning of event. (Subtract 4 hours to convert to EDT, 5 hours for CDT, 6 hours for MDT, and 7 hours for PDT.) **End Time:** Universal time at end of event. **Event:** The nature of the event and the objects involved. **Type of event:** Whether the event is partial, total, or annular, or a disappearance or reappearance. **Light Loss:** For eclipses — the percent of light lost by the eclipsed satellite at midevent; For occultations — the percent of light lost from the combined light of both satellites at midevent. **Distance:** The apparent distance of the satellite from Saturn's center expressed in Saturnian equatorial radii.

Donald C. Parker

Date	Begin Time	End Time	Event	Type of Event	Light Loss	Distance
November 23	0h16.5m	0h19.9m	Dione eclipses Enceladus	Partial	74%	3.9
November 24	1h34.2m	1h36.2m	Tethys eclipses Mimas	Partial	94%	2.5
November 24	3h41.4m	3h43.3m	Saturn eclipses Dione	Reappearance	—	1.6
November 25	22h51.4m	22h53.4m	Tethys eclipses Mimas	Partial	84%	2.5
November 25	23h42.7m	23h45.7m	Saturn eclipses Rhea	Reappearance	—	1.8
December 2	8h48.6m	8h50.5m	Saturn eclipses Dione	Reappearance	—	1.6
December 4	8h53.6m	9h08.7m	Saturn eclipses Titan	Reappearance	—	2.9
December 4	8h54.2m	9h03.5m	Dione eclipses Rhea	Annular	54%	5.7
December 5	0h39.0m	0h42.0m	Saturn eclipses Rhea	Reappearance	—	1.8
December 5	2h31.1m	2h32.9m	Saturn eclipses Dione	Reappearance	—	1.6
December 7	6h34.4m	6h35.7m	Tethys eclipses Mimas	Partial	23%	2.4
December 9	3h51.4m	3h52.7m	Tethys eclipses Mimas	Partial	21%	2.4
December 11	1h08.5m	1h09.9m	Tethys eclipses Mimas	Partial	12%	2.3
December 11	3h39.5m	3h45.2m	Rhea eclipses Dione	Partial	31%	6.3
December 12	22h25.5m	22h26.9m	Tethys eclipses Mimas	Partial	12%	2.3
December 13	7h38.3m	7h40.1m	Saturn eclipses Dione	Reappearance	—	1.6
December 14	1h35.2m	1h38.3m	Saturn eclipses Rhea	Reappearance	—	1.8
December 16	0h59.9m	1h02.5m	Rhea eclipses Mimas	Partial	98%	2.6
December 16	1h20.6m	1h22.5m	Saturn eclipses Dione	Reappearance	—	1.6
December 20	8h03.1m	8h18.6m	Saturn eclipses Titan	Reappearance	—	2.8
December 23	2h31.6m	2h34.7m	Saturn eclipses Rhea	Reappearance	—	1.8
December 25	7h13.7m	7h16.0m	Dione eclipses Tethys	Partial	12%	3.9
December 26	3h24.7m	3h26.0m	Tethys eclipses Mimas	Partial	5%	2.2
December 28	0h41.7m	0h43.0m	Tethys eclipses Mimas	Partial	5%	2.1
January 1	3h27.6m	3h30.6m	Saturn eclipses Rhea	Reappearance	—	1.8
January 5	7h11.0m	7h26.9m	Saturn eclipses Titan	Reappearance	—	2.6
January 10	4h23.5m	4h26.6m	Saturn eclipses Rhea	Reappearance	—	1.7
January 19	5h19.3m	5h22.4m	Saturn eclipses Rhea	Reappearance	—	1.6
January 20	22h26.7m	22h32.7m	Tethys occults Dione	Partial	41%	4.9
January 21	6h16.9m	6h33.5m	Saturn eclipses Titan	Reappearance	—	2.4
January 25	4h21.2m	4h23.2m	Mimas eclipses Enceladus	Annular	44%	2.8
January 29	5h30.4m	5h33.0m	Tethys eclipses Enceladus	Partial	100%	3.5
February 6	5h20.5m	5h38.1m	Saturn eclipses Titan	Reappearance	—	2.0
February 6	23h42.7m	23h50.0m	Dione eclipses Tethys	Partial	36%	4.8
February 9	0h20.7m	0h23.4m	Tethys occults Dione	Partial	37%	4.0
February 10	23h18.8m	23h20.0m	Tethys occults Rhea	Partial	2%	3.2
February 12	23h54.5m	0h26.2m	Dione occults Enceladus	Total	22%	2.5
February 13	0h43.9m	1h46.2m	Dione occults Enceladus	Total	22%	3.1
February 13	3h43.5m	3h45.2m	Rhea occults Mimas	Total	6%	2.3
February 18	1h45.7m	1h48.4m	Enceladus eclipses Tethys	Partial	13%	3.9
February 27	2h09.5m	2h10.5m	Mimas occults Tethys	Partial	6%	2.4
May 6	12h40.4m	12h43.8m	Saturn eclipses Rhea	Disappearance	—	1.6
May 13	12h03.9m	12h06.9m	Enceladus eclipses Mimas	Partial	50%	3.0
June 5	9h16.9m	9h19.0m	Saturn eclipses Dione	Disappearance	—	1.6
June 16	4h51.4m	4h55.1m	Saturn eclipses Rhea	Disappearance	—	1.9
June 16	8h04.5m	8h06.5m	Saturn eclipses Dione	Disappearance	—	1.6
June 25	5h47.3m	5h51.1m	Saturn eclipses Rhea	Disappearance	—	1.9
June 27	6h52.0m	6h54.1m	Saturn eclipses Dione	Disappearance	—	1.6
July 4	6h43.3m	6h47.3m	Saturn eclipses Rhea	Disappearance	—	1.9
July 5	11h57.7m	11h59.8m	Saturn eclipses Dione	Disappearance	—	1.6
July 8	5h39.6m	5h41.7m	Saturn eclipses Dione	Disappearance	—	1.6
July 13	7h39.5m	7h43.5m	Saturn eclipses Rhea	Disappearance	—	1.8
July 16	10h45.4m	10h47.5m	Saturn eclipses Dione	Disappearance	—	1.6
July 19	4h27.3m	4h29.5m	Saturn eclipses Dione	Disappearance	—	1.6
July 22	8h35.8m	8h40.0m	Saturn eclipses Rhea	Disappearance	—	1.8
July 27	9h33.2m	9h35.4m	Saturn eclipses Dione	Disappearance	—	1.6
July 30	3h15.2m	3h17.4m	Saturn eclipses Dione	Disappearance	—	1.5
July 31	9h32.4m	9h36.7m	Saturn eclipses Rhea	Disappearance	—	1.7
August 9	10h29.2m	10h33.6m	Saturn eclipses Rhea	Disappearance	—	1.6
August 18	11h26.3m	11h30.9m	Saturn eclipses Rhea	Disappearance	—	1.5

The character of a mutual event depends on the geometry of the satellites relative to the Sun and Earth. An event is partial when one satellite or its shadow just skims another satellite. When one satellite blocks the entire disk of another or its shadow completely envelops the other, the event is total. And an annular event occurs when one satellite appears entirely within the disk of another or its shadow is entirely contained within the disk of the eclipsed satellite.

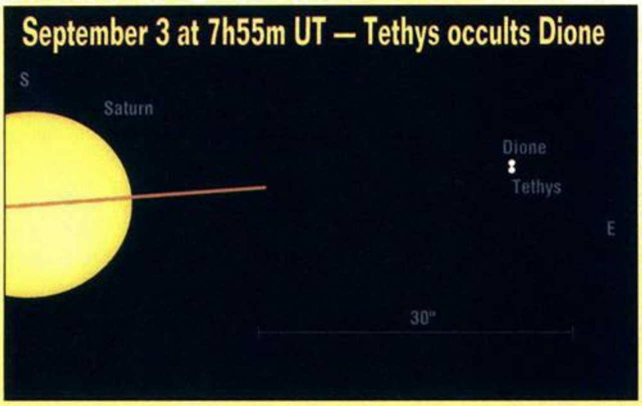
Other factors that set mutual events apart are when they occur, which determines the places on Earth where they are easiest to view; how long they last; and the maximum amount of dimming. Because the six Saturnian satellites are fairly faint, the light loss must be significant to be observed easily. At the eyepiece of a 6-inch telescope, a light drop of 30 percent or less is hard to see; one of 30 to 50 percent requires comparing the brightness of the affected satellite with other satellites; a drop of 50 to 90 percent appears obvious; and a dimming of more than 90 percent makes a satellite seem to disappear.

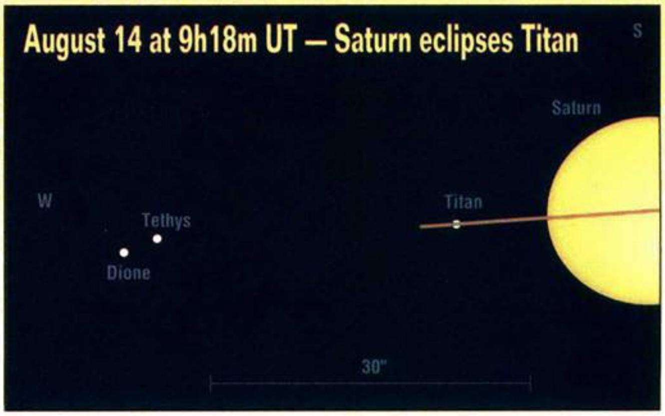
Every eclipse of a satellite by Saturn is total. The chief difference in how they appear depends on whether the satellite disappears into Saturn's shadow or re-emerges from the shadow. Because of the geometry of the Sun, Earth, and Saturn, satellite reappearances occur between September 14, 1995, and March 17, 1996, and disappearances occur before and after this period.

The table on the preceding two pages lists the mutual events and Saturnian eclipses from August 1 until the events end in 1996. Only events that feature a light loss of at least 5 percent and can be seen from all or part of North America are included. (Those living elsewhere can receive a copy of the other events by writing to ASTRONOMY or e-mailing us at rtalcott@astronomy.com.)

One of the more interesting events comes on August 9, when Enceladus occults Rhea annularly. The light from the pair will drop by 9 percent as Enceladus zips across the other satellite in less than two minutes. Another good event arrives on September 24 when Tethys eclipses Rhea. The brightness of Rhea dips significantly, by 47 percent, at peak eclipse.

Perhaps the best sequence of events comes on November 9 and 10, when Titan totally eclipses Mimas twice and Enceladus once. The light of the smaller, fainter satellites disappears as Titan's large shadow engulfs them. For those in North America, only the middle event (an eclipse of Mimas), can be seen easily.


September 3 at 7h55m UT — Tethys occults Dione


August 14 at 9h18m UT — Saturn eclipses Titan

A spectacular pair of events comes on November 20 when, within the space of half an hour, two satellites eclipse two others. First up, Dione eclipses Enceladus for a little more than three minutes. Then after a short break, Tethys eclipses Mimas. Although both events are partial, they are so close to total that the light of the eclipsed satellites drops 100 percent.

Just four days after these events, everyone in North America can watch Dione reappear from out of Saturn's shadow. But probably the best eclipse by Saturn comes on August 14, when bright Titan disappears into the planet's shadow.

How much you see of an event depends on the size and quality of your telescope, the seeing conditions that night, and your observing skills. Although the satellites will appear as unresolved points of light even under excellent conditions (even the biggest, Titan, measures only 0.8" across), you'll want to use a fairly high magnification (up to 30x per inch of aperture). That will help separate the satellites better so you can more clearly see what's going on. In a mutual occultation, you will see the two moons approach one another and merge into a single elongated image having the combined brightness of the two satellites. This bright, elongated image then grows fainter and more circular, although the dimming may not appear obvious. The two stages then play out in reverse order, with the image growing brighter and more elongated until the two satellites finally separate.

The only satellite of interest during a mutual eclipse is the one being eclipsed. But if the eclipse features a small drop in brightness, you'll need to compare the eclipsed satellite's brightness with those of other nearby satellites. The apparent visual magnitudes of the six satellites at opposition are Mimas at magnitude 12.9, Enceladus at 11.7, Tethys at 10.2, Dione at 10.4, Rhea at 9.7, and Titan at 8.3.

You can also try recording an eclipse or occultation with a series of photographs. For the best results, practice photographing the satellites with the same setup you plan to use for the event. (See "High-Impact Astrophotography" by Mark Coco, April 1994, for tips on photographing the planets.)

Photographing or sketching a satellite event can be rewarding and can give you a lasting souvenir of the event. But don't let your attempt to record the view get in the way of enjoying the view. These events come in cycles spaced a healthy 15 years apart, so they are far too fleeting not to be relished. □

BIG SKY Deep-sky

Stellar associations and their attendant gas clouds cover huge tracts of the night sky. Some observers look right at these leviathans without even realizing it.

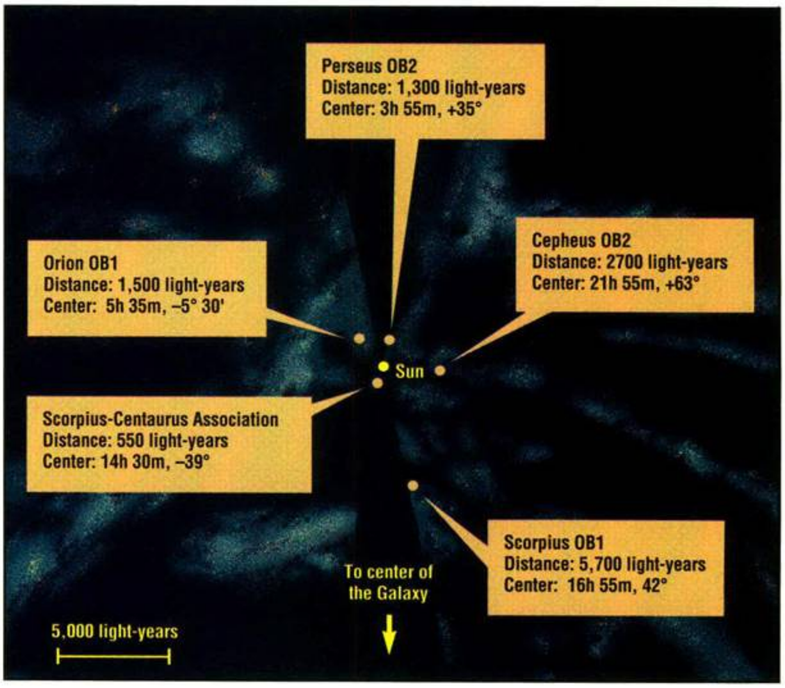
by Craig Crossen

Say "deep-sky observing" and many people think of someone squinting through a telescope's eyepiece. Deep-sky objects imply telescopic targets found with a wide-angle eyepiece and best scrutinized with a high-power eyepiece.

Well, keep the star-filled sky, but forget the eyepieces. There's a class of deep-sky target that isn't quite as small as the rest. They often go unnoticed, even though they have many exciting naked-eye and binocular objects within them. This "undiscovered" deep-sky target is called a stellar association.

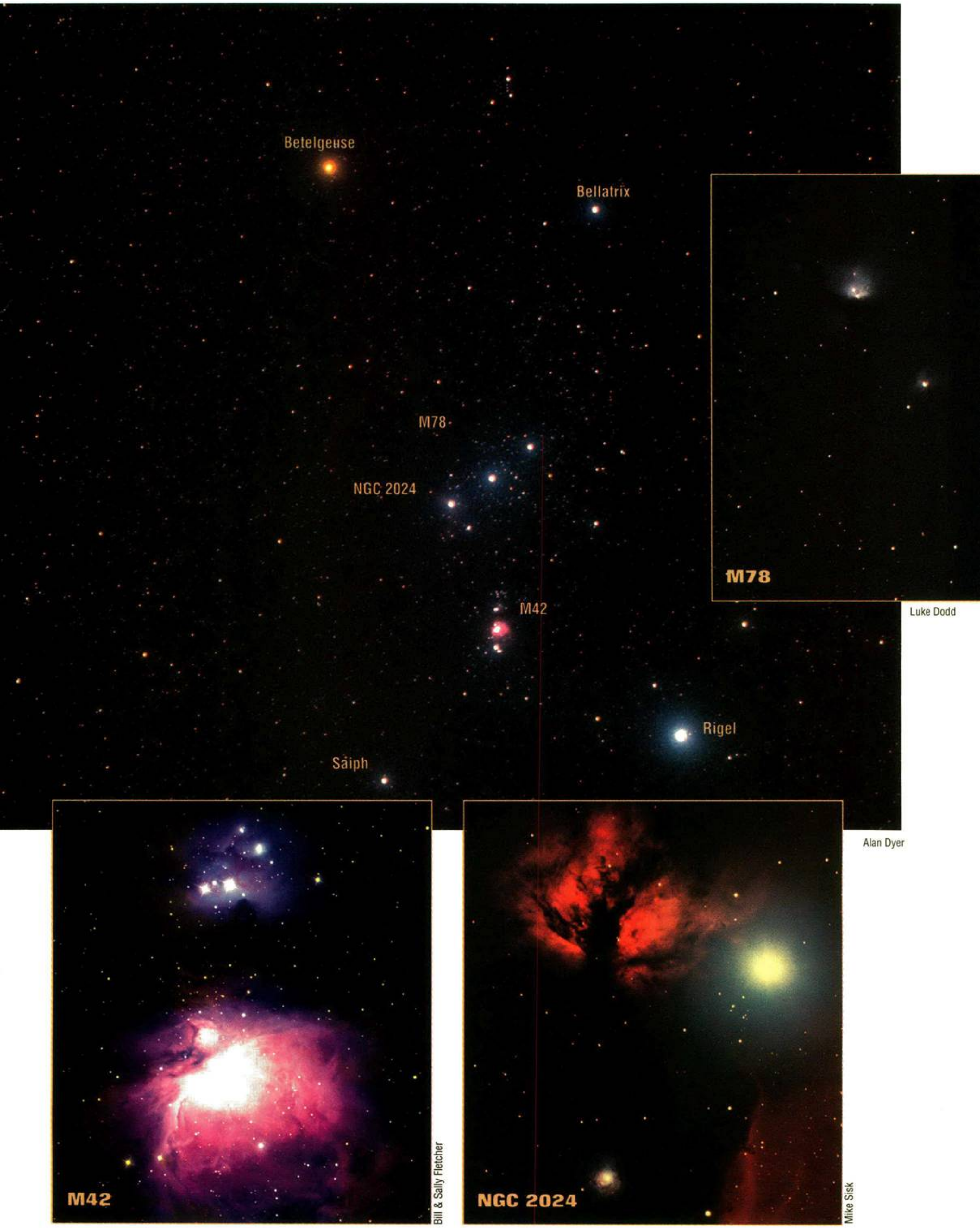
Stellar associations are assortments of young stars of the same spectral type moving together through our galaxy, born of the same cloud of gas and dust. Their shared motion is left over from the parent cloud's original motion. Unlike open star clusters, stellar associations are large, sometimes hundreds of light-years across. Younger associations are also affiliated with bright emission nebulae and dark dust clouds, lingering remains of the interstellar dust and gas from which they coalesced. The stars that make up associations and the glowing gas clouds offer up many nights of interesting naked-eye and binocular observing.

You've probably looked right at an association without even realizing it. The broad-shouldered, starry-belted figure of Orion the Hunter, brightest constellation in the heavens, is not entirely the result of chance. Nearly all the bright stars in Orion are mem-


Perseus OB2
Distance: 1,300 light-years
Center: 3h 55m, +35°
Cepheus OB2
Distance: 2700 light-years
Center: 21h 55m, +63°
Orion OB1
Distance: 1,500 light-years
Center: 5h 35m, –5° 30'
Sun
Scorpius-Centaurus Association
Distance: 550 light-years
Center: 14h 30m, –39°
Scorpius OB1
Distance: 5,700 light-years
Center: 16h 55m, 42°
To center of the Galaxy
5,000 light-years

STELLAR ASSOCIATIONS SURROUND the Sun's neighborhood at different distances. Most lie along a zone called Gould's Belt, the existence of which tells astronomers that a large supernova triggered a burst of star formation in our region of the Galaxy 70 million years ago

MOST OF ORION'S STARS make up the Orion OB1 stellar association. Non-members Bellatrix and Betelgeuse are actually closer to Earth. Co-mingled deep-sky objects like M78 and NGC 2024 hint at the association's relatively young age. The Orion Nebula, M42, marks its heart.


Betelgeuse
Bellatrix
M78
NGC 2024
M42
Rigel
Saiph
M78
M42
NGC 2024

Luke Dodd

Alan Dyer

Bill & Sally Fletcher

Mike Sisk

Gerald Rhemann

LURKING IN THE DARK with eons of star formation ahead of it, the Perseus OB2 association includes NGC1499, the California Nebula.

bers of the Orion OB1 association, which lies between 900 and 2,100 light-years distant. At its very heart is the Orion Nebula, M42, visible to the unaided eye as a small fuzzy patch of light surrounding the middle star in the Hunter's sword, 4th-magnitude Theta (θ) Orionis.

About 2 1/2° northeast of the Hunter's easternmost belt star Zeta (ζ) Orionis lies M78, a dust cloud that shines by the light of nearby stars. Glimpsed in binoculars under a dark sky, the nebula is embedded in an obscuring cloud of heavy dust about 1° in diameter. Scan across M78 to see other areas of the cloud not lit by starlight, which obscure star fields beyond it. Gas clouds giving off their own light lie just east of Zeta (NGC 2024) and around the northern stars in the Orion's sword, 42 and 45 Orionis (NGC 1977).

This association's fully formed stars mixed with a smattering of nearby glowing gas and tells us it didn't form at the same time. Orion's bright and dark nebulae mark the fragments of a huge gas and dust complex from which most of the constellation's bright stars formed. Star formation still goes on in the Orion Nebula, where stars began shining only about 100,000 years ago. On the other hand, the bright blue supergiants in Orion's belt formed five million years ago.

Astronomers aren't sure if the stars of Orion's shoulders, Bellatrix and Betelgeuse, are true members of Orion OB-1. Bellatrix almost certainly is not, because its estimated distance, 470 light-years, is less than a third to that of the belt and sword, the association's center. Betelgeuse's membership is a little more ambiguous. It is a massive, luminous red star with the same motion through space as other association members. However, its distance is no farther than 650 light-years, less than half as far as the belt and sword. Because of this, astronomers feel that Betelgeuse is not a member.

The Scorpius-Centaurus Association is even nearer to us than Orion OB1 and includes almost all of the bright stars in the constellations Centaurus, Crux, Lupus, and Scorpius. This group lies about 550 light-years away, about one-third the distance to Orion OB1. It even looks close: This association covers an area about 70° long and 20 to 25° wide, centered between the bright stars Alpha (α) Lupi and Zeta (ζ) Centauri.

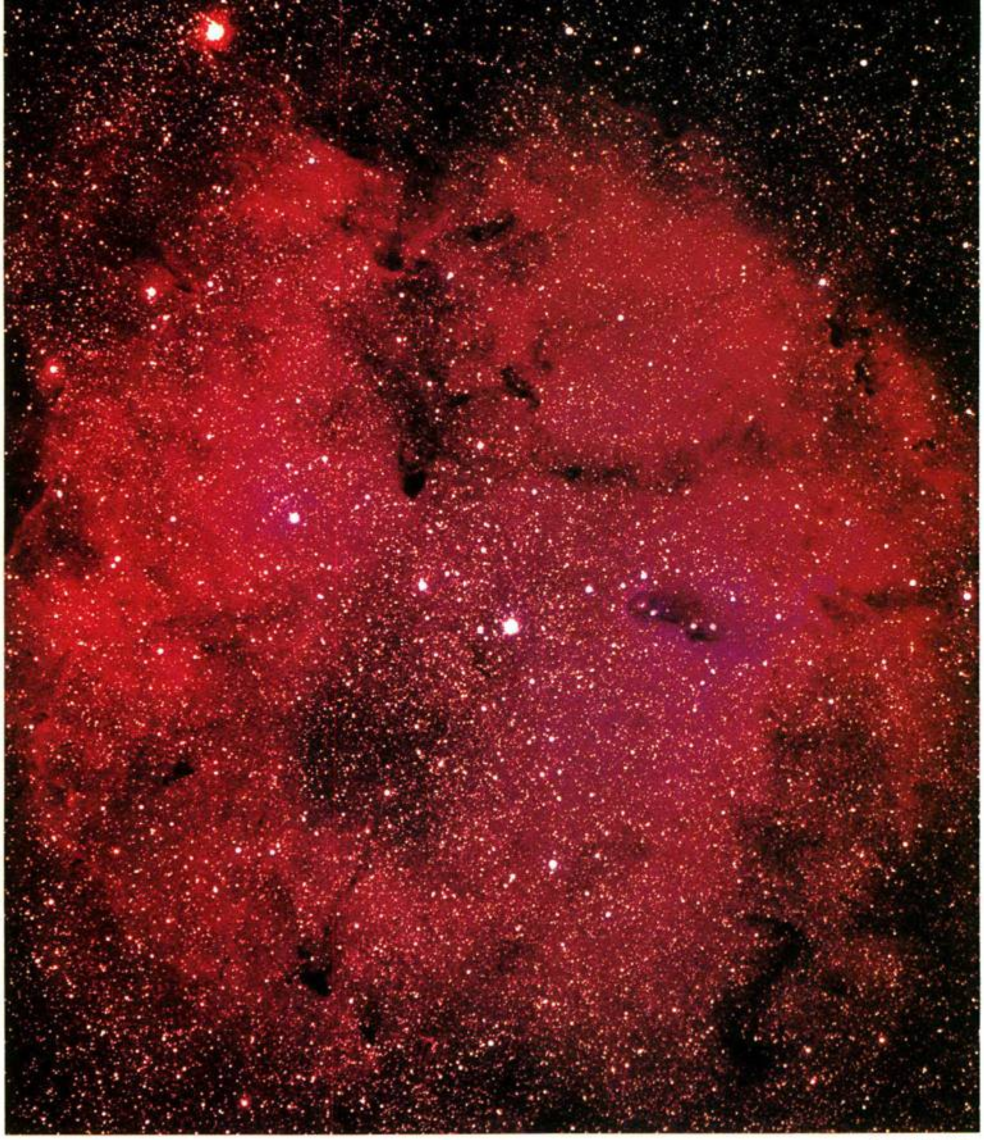
This association's brightest stars are about 20 million years old, roughly four times older than the supergiant stars in Orion's belt. The absence of bright emission nebulae and heavy dust clouds also betrays the association's age. Stellar winds from young stars swept most of this gas and dust out of the group long ago.

If you extend the central line of the Scorpius-Centarus Association northeast beyond Antares and Scorpius, it continues all around the sky and passes through other nearby stellar associations. This great circle of associations is called Gould's Belt, named for 19th-century astronomer Benjamin Apthorp Gould, who first glimpsed this macrostructure in the Milky Way.

Astronomers suspect that this belt had its origin some 70 million years ago when a supernova in our region of the Galaxy sent a shock wave through interstellar gas and dust, initiating an expanding ring of star formation that continues to this day. Astrophysical musings aside, it's fun to stroll Gould's Belt and take in its varied and more subtle members.

As Gould's Belt threads through the northern Milky Way, we see the Perseus OB2 Association, centered about 1,300 light-years away. This group is a loose gathering of 3rd-, 4th-, and 5th-magnitude stars in a 5° field around the star Zeta (ζ) Persei.

As associations go, Perseus OB2 is not very large (only about 100 light-years across) and not very populous. However, astrophotos reveal a great deal of bright and dark nebulae in the area, including the California Nebula, NGC 1499, which is just north of Xi (ξ) Persei and visible in 10x50 binoculars under clear, dark skies. Because this is such a very young group (just over a million years old), Perseus OB2 has most of its star-rich and luminous years still ahead of it.



George Greaney

A GARNET STAR nestled in nebulosity marks the heart of the Cepheus OB2 association. Newborn stars make this normally dark gas glow.

Continuing along the Milky Way, we come upon the Cepheus OB2 association in the extreme southern part of the constellation Cepheus. Nestled in an area enclosed by Alpha (α), Beta (β), Iota (ι), and Zeta (ζ) Cephei, Cepheus OB1's rich field of 4th-, 5th-, and 6th-magnitude stars stand out against the Milky Way's background glow.

Centered about 2,700 light-years away, the group is visually anchored by the very red "Garnet Star" Mu Cephei. While the presence of this red supergiant indicates the association is somewhat evolved, an extremely young star, Lambda (λ) Cephei, hints that star formation is still happening in this region. Nearby, a very faint gas cloud, IC 1396, is lighting up with new stars. This smudge of light covers an area about 2° across and is just visible in large binoculars.

The four major associations we've talked about so far are visible to the unaided eye and provide some of the finest binocular star fields in the heavens. This next association requires binoculars to be fully appreciated.

If it were placed farther north, the Scorpius OB1 Association would be as famous as the Double Cluster in Perseus. Its showpiece object, the 5th-magnitude open cluster NGC 6231, anchors an area that's only one degree across and centered within fifteen 5th, 6th, and 7th magnitude stars. The brightest of theses stars is magnitude-4.8 Zeta^1 (ζ^1) Scorpii, which has a true luminosity of 250,000 Suns, one of the intrinsically brightest stars known.

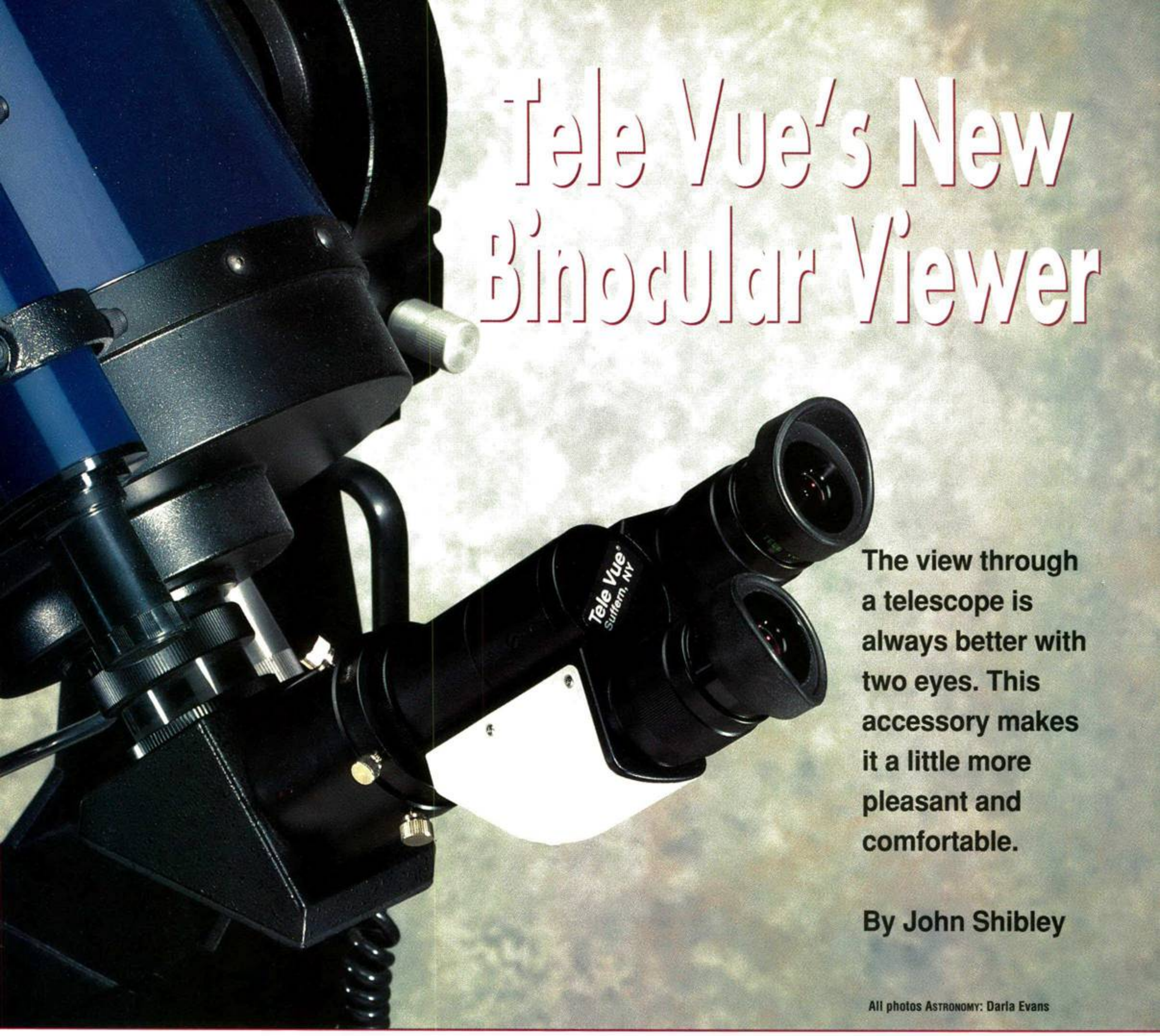
In binoculars Scorpius OB1 looks elongated southwest to northeast, from Zeta^1 Sco on the southwest up through NGC 6231 on the northeast. This elongation runs parallel to the plane of the Galaxy, southwest to northeast through the tail of the Scorpion. Its shape might be the signature of tidal stresses in our galaxy.

Subtleties like these show that observing associations are just as rewarding as any telescopic deep-sky observing. If hunting associations has whetted your appetite for the large and obscure, don't bury your eyes behind an eyepiece quite yet. There are plenty of large-scale objects in the sky just waiting for discovery.

Pick up a detailed star atlas like *Sky Atlas 2000.0* and go for those large, blobby features marked on the charts. Find out what you can see with binoculars or eyes alone, using stellar associations as a springboard into the world of "macro" deep-sky observing. Instead of pumping the power, step back and give 1x a try! ☐

Craig Crossen gets his fill of deep-sky objects under the rural skies of Princeton, Minnesota.

Tele Vue's New Binocular Viewer



The view through a telescope is always better with two eyes. This accessory makes it a little more pleasant and comfortable.

By John Shibley

All photos Astronomy: Darla Evans

We're put on this Earth with two eyes, so why squint at the universe with one eye through a telescope? Al Nagler, premium telescope and eyepiece manufacturer, recently asked that same question. Seeing no reasonable answer, he introduced the Bino Vue binocular viewer.

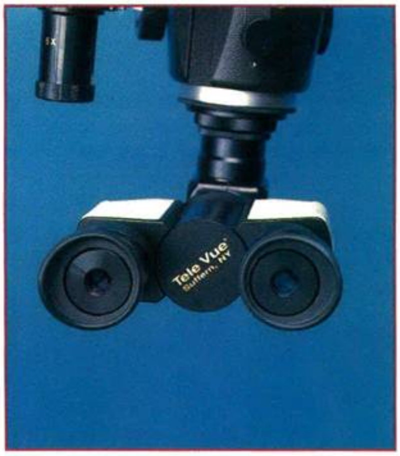
Binocular eyepiece viewers have been around for decades. The base design splits a single image from the scope's main optics and sends it to two eyepieces. Thus, as with conventional binoculars, you observe with both eyes, which increases comfort and lessens eye strain. With an image coming from each eye, the brain heaves a sigh of relief and processes detail with greater definition.

Two features make the new Bino Vue different from anything on the market. First, there's no need to refocus after adjusting the interocular distance, the separation between an observer's eyes. Second, while most binocular viewers tilt the optical path 45°, Bino Vue passes light straight through. This offers greater ease when using it with a Newtonian reflector. With a Schmidt-Cassegrain or a refractor, the viewer slips into any 1¼-inch star diagonal.

Bino Vue uses a variant of the roof prism design found in most compact, straight-through binoculars. The prism's fully multicoated optical surfaces help improve image contrast. There were no spurious reflections when I looked through the empty eyepiece holders at an overhead fluorescent light panel. I also didn't see any edge cut-off or vignetting (a benefit of the viewer's BaK4-type prism).

Another important Bino Vue attribute is weight. At just over a pound, it doesn't require a major rebalancing of the telescope tube, even when you add on the weight of two eyepieces. The viewer's aluminum and PVC plastic construction helps keep this weight down.

Overall, Bino Vue is 7¼ inches long, from the chrome tube that locks into the telescope's focuser, to



Tele Vue
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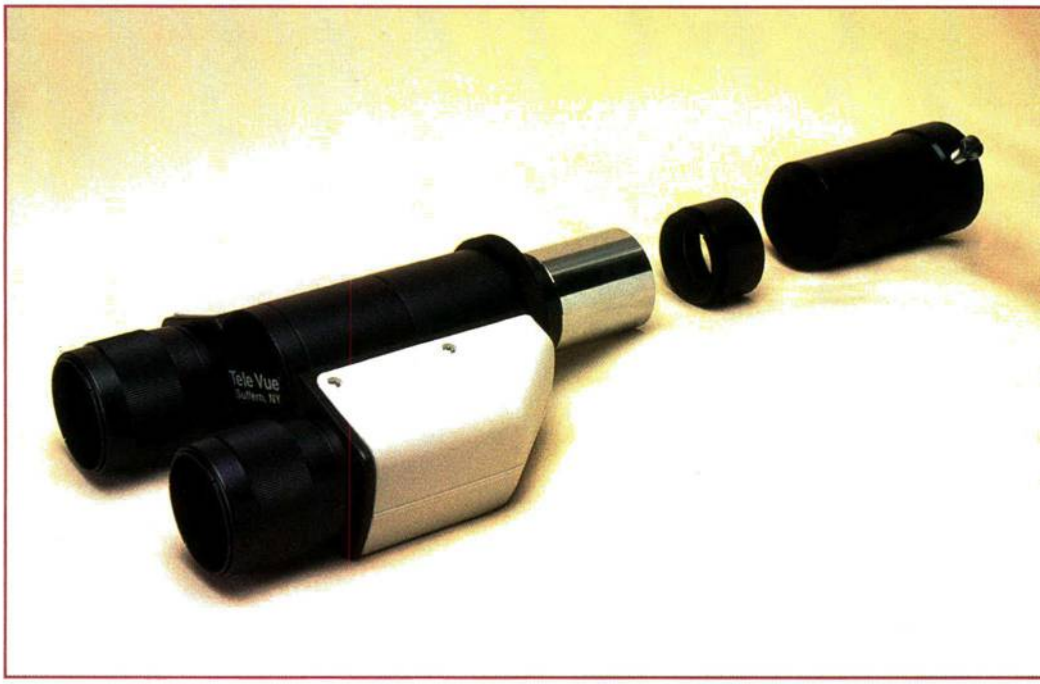
EASY TO ADJUST, BINO VUE'S interocular adjustment works like conventional binoculars and requires no refocusing.



A REMOVABLE BARLOW LENS lets Bino Vue work with a variety of telescope designs. The threaded lens (center) also fits into a Barlow tube (right) to create a 2.5x Barlow you can use with other 1¼" eyepieces.

the 1¼-inch eyepiece holders. Its 4½-inch width accommodates large (or gloved) hands, which is important when it comes to adjusting distance between the eyepieces. I was able to change this distance as easily as one would adjust binoculars, in one fluid motion. Measuring from the center of each eyepiece holder, the interocular distance adjusts from 2¼ inches to 3 inches.

Each eyepiece holder has a clamp ring to lock eyepieces into place. If one eye focuses slightly different than the other, focus as you would with binoculars: First, focus the telescope for one eye, then loosen the other eyepiece's lock ring and slide the eyepiece in or out until the image looks sharp, and retighten the ring. Now the scope will focus for both eyes.

The Bino Vue incorporates a Barlow lens that lets it work with low f/ratio telescopes, such as f/5 or less. Such scopes need this lens because, given the 5½ inches the viewer adds to the optical system, few focusers rack in enough to reach focus.

The Barlow magnifies 3.8 times, which means that observers with fast Dobsonians will always use Bino Vue at magnifications greater than 100. For example, the lowest power I obtained using the viewer with 32mm Plössls on a 13.1-inch f/4.5 Dobsonian was 175x. In this light, the viewer becomes more of a tool for scrutinizing deep-sky objects rather than a means for rich-field observing.

This magnification effect is less noticeable with small refractors, such as Tele Vue's Pronto and Genesis refractors, which when fitted with 32mm Plössls yield more comfortable magnification levels of 57x and 64x, respectively.

I didn't consider the higher magnification threshold a hindrance with my 13.1-inch f/4.5 Dobsonian. Observing with both eyes allowed me to confirm tiny planetary nebulae such as NGC 6826 in Cygnus and spot lots of detail on the Moon

One bonus gained from the higher magnification is an increase in contrast. This made it easier to detect subtleties in small, bright planetary nebulae like Draco's NGC 6543.

The Barlow lens becomes optional with telescopes that have higher focal ratios, such as 8-inch f/10 Schmidt-Cassegrains. When this lens is not needed, it threads into a Barlow tube that Tele Vue includes with the viewer, giving you a 2.5x Barlow lens that accepts 1¼-inch eyepieces.

This interchangeability, along with straight-through viewing and no refocusing after interocular adjustment, means Bino Vue sits in a league of its own among binocular viewers. With an average retail price of around $900, it runs about a third more than other viewers.

But while looking at the open cluster M11 in Scutum one frosty spring morning, when my mind shaped the view into a 3-D spattering of tiny star points, I did some arithmetic. Forty more years in this hobby . . . that works out to about $22.50 a year. Maybe observing with two eyes isn't that pricey after all! □

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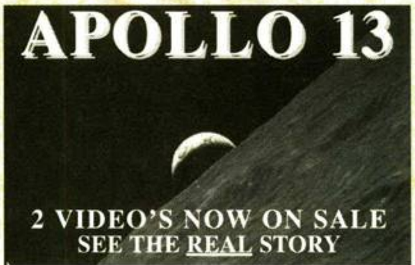

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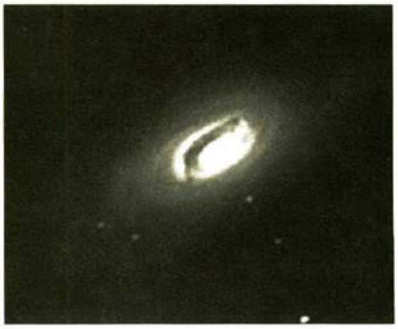

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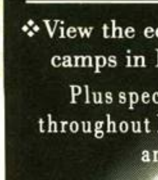

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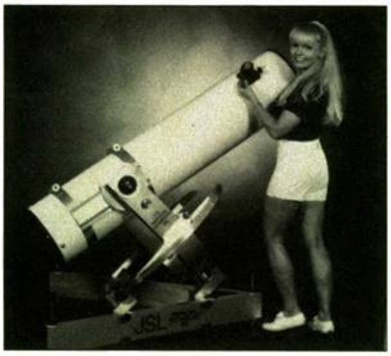

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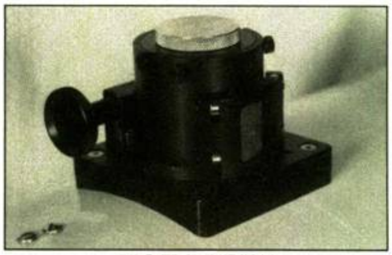

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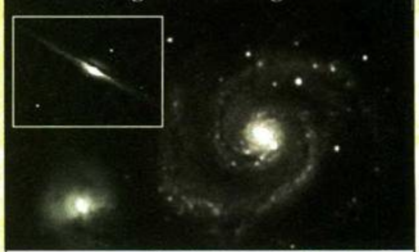

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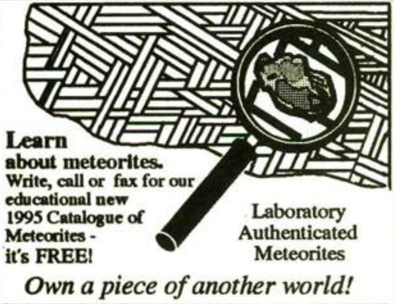

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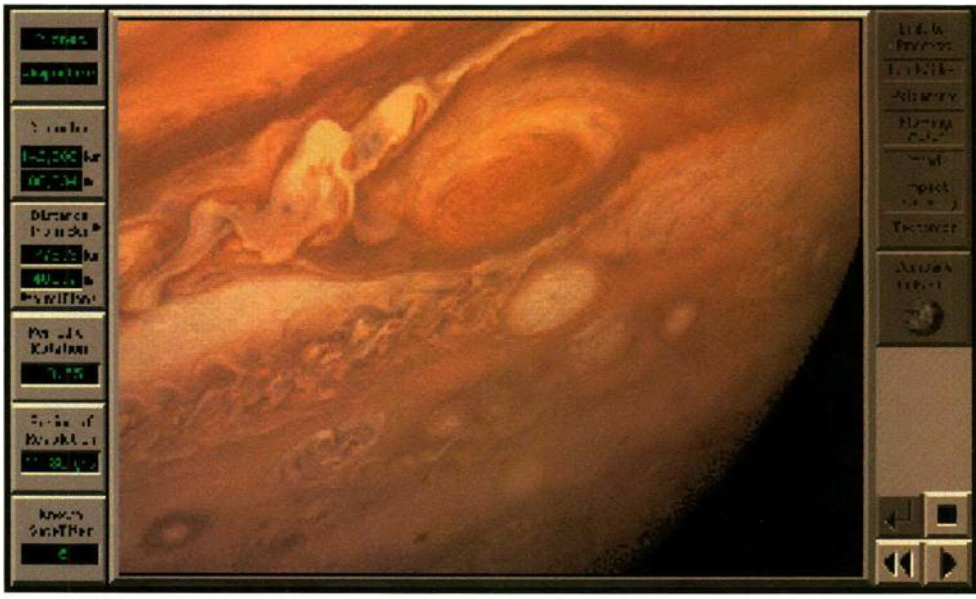

Explore the Planets

TASA Graphic Arts, 11930 Menaul Boulevard, Suite 107, Albuquerque, NM 87112-2461, (505) 293-2727, fax (505) 293-5757. Price: $85 (multi-user site license: $155). This CD-ROM will work on both PCs and Macs. Minimum requirements for PCs: 80386-based computer, Super VGA display, CD-ROM drive, 4 MB of memory, and Windows 3.0 (3.1 for use with sound boards); Macs: Mac IIci with color graphics, CD-ROM drive, 4 MB of free memory, System 6.0.7.

Intended for use in schools, *Explore the Planets* will also be a hit with armchair astronomers who want to learn more about the processes that shaped the surfaces of planets. Written by G. Jeffrey Taylor of the University of Hawaii's Institute of Geophysics and Planetology, the CD-ROM has four main sections: an "Introduction" to the solar system and how it formed, "Planet Processes," a "Tour of the Planets," and a game section called "Explorer." A glossary and planet data table comprise the ancillary sections.

"Tour of the Planets" enables the user to choose an in-depth tour of any of the nine planets, the Moon, or asteroids. Views include a cross-section of the planet's interior. Certain stops in the tour allow the user to compare a planet to Earth or its geological processes. For example, the tour of Mars shows that the diameter of Olympus Mons is about the same as the length of Florida (Olympus Mons wins in area though). During a tour, users can select "NASA news" to learn about past and future space missions to explore that planet.

"Planet Processes" describe geologic and atmospheric phenomena common to the planets, such as wind, landslides, flowing water, impact cratering, volcanism, and tectonics. "Explorer" shows images of a planet or satellite and asks the viewer to identify it. Certain data such as orbital period or diameter is also displayed to provide helpful clues as to the object's identity.

The presentation makes good use of multimedia, presenting animations, graphics, interactive plots, audio interviews, and films. Users can select text narration to listen to the words on the screen describing an object or process. Links are also used; for example, a section on Martian geology might use the word "graben" and highlight it in color. Clicking on the word will send the user to the glossary entry for the word. Another click and the computer plays a recording of the correct pronounciation of the word. A tutorial built into the program shows users how to navigate the program.

Explore the Planets has three levels that represent differing depths and breadths of knowledge: elementary (grades 3-6), advanced (7-12), and expert (college). Higher levels cover the same material as lower levels but add extra details or include new geological processes. The glossary also grows with higher levels.

This is a well-thought-out educational program that should find its way into many classrooms. It presents planetary science as it should be taught: not as memorization of facts about individual planets but as an exploration of similar processes on dynamic worlds. The depth of material will permit users to explore many facets of the planets and not easily tire of the CD-ROM. But don't think *Explore the Planets* is just for the classroom. Anyone with an interest in the planets will learn a lot from this superb multimedia package. — *Dave Bruning*

SuperFix

Bruce Johnstone, 7764 Tull Court, Waterford, MI 48327, (810) 666-2186. Price: $69.95 plus $4 for shipping and handling; demo disk is available for $3 in the United States and $5 elsewhere. Minimum requirements: 80286-based computer, VGA display, DOS 4.0, 540 KB of free conventional memory, and 1 MB of extended memory. Recommended: 80386-based computer, VESA Super VGA display, 2 MB of free space on a hard disk, and a mouse.

SuperFix is the 16-bit big brother to *PixFix*, an image-processing program for 8-bit CCD cameras. Actually, it's a suite of four image-processing programs that enhances images taken with Cookbook 211 and 245, Electrim EDC 1000, Lynxx PC, PXL-211, ST-4, ST-4X, ST-5, ST-6, and generic 8-bit CCD cameras.

SuperFix is also the name of one of the programs. Using some of the program's 80 functions, the user can calibrate an image using dark and flat-field frames, look at the histogram of brightnesses in an image, sharpen or blur an image, zoom in and out to examine details, rotate or flop an image, or resize an image. Other functions permit scaling brightnesses, masking the image including unsharp masks, and aligning two or more frames for coadding or for merging into a tricolor image. Advanced features include surface plots of the image, loop filters that alternate blurring and sharpening for enhancing an image, and image rotation for aligning images offset slightly by improper polar alignment.

Preview mode lets the user see the results of modifying the image without actually changing the image file. *SuperFix* has a "History track" option that keeps a log of operations performed on a particular image. This saves the user from having to remember which functions were applied in what order. The log is particularly useful for processing tricolor images so the same functions can be applied to each image and in the same order. The program can store processed images in the original camera format or in FITS, 32-bit FITS, SuperFix, TIFF, 320x200 TIFF, and PCX image-file formats.

The other three programs are *SuperCal, SuperTri,* and *SuperShow. SuperCal* automatically combines dark and flat-field frames and then applies corrections using these frames to image frames. The program also aligns and stacks multiple images of the same object. The user can select preview mode to choose only the best images to stack or all images.

SuperTri aligns three images taken through different color filters to combine them into a tricolor image. The software permits color balancing. *SuperTri* requires a VESA-compliant Super VGA display (640x480 with 16 million colors).

SuperShow creates a slide show of processed CCD images. The program allows the user to move forward and backward through a stack of images and to pause at any image.

Surfing the Net

Books about the Internet are flooding bookstores and computer shops. Some provide directories of resources on the network and others give general background about the network and the various tools used to access resources. But few of these aim at science users.

The Internet for Scientists and Engineers by Brian J. Thomas (SPIE Press, 1995) guides novice and experienced users to resources in science on the network. Armchair and backyard astronomers will find it easy to read and not particularly geared to professional scientists. The book includes information about how getting connected, sending e-mail, joining discussion lists, transferring files, searching for resources, and accessing the World Wide Web, the best means for browsing the material on the Internet. It also includes extensive lists of Internet resources on astronomy, optics, and space.

The 450-page book costs $30. For a copy, contact SPIE Press, P.O. Box 10, Bellingham, WA 98227-0010, (360) 676-3290.

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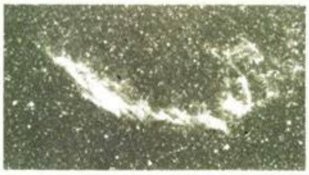

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Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.

Declination motor (state telescope)	**$109**
Variable dec. speed drive w/built-in 5AH battery	**$299**

HYPERSENSITIZED FILM

SR1600
Scotch
1000
NEW
SRV3200

YES! WE STILL HAVE FUJI HG400!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$14.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	12	**$14.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

LUMICON® ACCESSORIES | MEADE® TELESCOPES

TOLL-FREE ORDER LINE 1-800-767-9576 EXPERT INFORMATION 1-510-447-9570 FAX 1-510-447-9589
LUMICON, 2111 Research Drive, Suites 4-5, Livermore, CA 94550 OPEN M-F 9-5, SAT 11-3 PST

LED FLASHLIGHT $14.95

LUMICON LUMILITE™ Red LED Flashlight

This red LED flashlight preserves night vision. It uses 2 AA cells (included!) which last 60-100 hours.

LUMILITE red LED flashlight	**$14.95**

DRIVE CORRECTORS

LUMICON
UNITRAK

LUMICON UNITRAK DRIVE CORRECTOR

Operate your telescopes ***anywhere!*** Use the single-axis Unitrak with a 12V DC car battery. The dual-axis drives are for photography and use either 12V DC or 125V AC.

Unitrak™ single-axis corrector	**$99.95**
LUMICON DX200 dual-axis correc.	**$249.00**
DX2BP incl. battery & charger ...	**$298.00**
Convenient rechargeable Porta-Pac battery:	
12V DC Porta-Pac (5AH) & recharger	**$79.50**
12V DC Porta-Pac (12AH) & recharger	**$99.50**

48MM COLORED FILTERS

FOR EVERY NEED

Select 48mm UV, Red, Yellow, Green (ea.)	**$19.95**
48mm Cyan (absorbs red)	**$69.00**
48mm High Performance Blue (95% T)	**$49.00**
48mm Tri-Color Blue (80% T- 400nm) .	**$49.00**
48mm Ultraviolet (85% T- 370nm)	**$49.00**
Color Separation Set: cyan, red, yellow, blue	**$149**

RICH FIELD! 2° in 8'' SCT

NOW ONLY
$99.50

LUMICON Rich-Field Viewer on C-8 with LUMICON 2'' star diagonal and 2'' eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2'' or 1¼'' eyepieces. It is available in several combinations depending on the eyepiece and field-of-view you desire (see chart below).

LUMICON Rich-Field Viewer	**$99.50**
Giant Rich-Field Viewer (10-14'') ..	**$250.00**

Optional Eyepiece	**TRUE FIELD**	**Price**
Meade 32mm Plossl	1.4°	**add $99**
Meade 32mm 2'' Wide-Field†	1.9°	**add $439**
Meade 40mm 2'' Wide-Field†	2.4°	**add $498**

†Includes 2'' enhanced aluminum Star Diagonal (may not reach focus on some telescopes).

PROTECTIVE DUST COVERS

Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼'' O.D. plug, seals focuser	**4/$2**		
2'' O.D. plug	**2/$2**	3½'' O.D. plug	**$1.50**
1¼'', 1⅜'' ...	**3/$2**	7½''	**$10**
1½''	**2/$2**	9½'', 10.4''*	**$15**
2''	**2/$2**	12½'', 12⅞''* ...	**$20**
2⅛''	**2/$20**	15.6'', 16''*	**$28**
5½''	**$6**	19'' (DS-16)	**$35**
*Fits Odyssey		21'' (Odyssey-II)	**$35**

MEADE 8'' - 16'' LX200 SCHMIDT-CASSEGRAINS

16'' LX200 $14,950
8'' LX200
$2495

NEW Meade 8'' LX200 Telescopes

LX100 - includes wedge, best for photography.
LX200 - full computer control w/64K obj. mem.
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your Schmidt-Cassegrain.

8'' **LX100** with wedge ($105 P&S)	**$2095**
8'' **LX200** w/computer ($105 P&S)	**$2495**
Wedge for photographing w/8'' LX200 ..	**$139**
10'' **LX100** w/super wedge ($145 P&S) .	**$2895**
10'' **LX200** w/computer ($145 P&S) ...	**$2895**
12'' **LX200** (f/10 only)($215 P&S)	**$3995**
Super Wedge for photogr. w/10'',12'' LX200	**$395**
16'' **LX200** f/10 w/tripod ($385 P&S) .	**$14,950**
Dew Shields: 8'' ..... **$119;** 10''	**$129;**
12'' ..... **$189;** 16''	**$289**

OTHER SCHMIDT-CASSEGRAINS

Meade 2045D 4'' f/10 w/motor ($40 P&S)	**$699**
Meade 2080B 8'' f/10 w/tripod, wedge, MCOG ($95 P&S)	**$1249**
Model 2120B 10'' f/10 w/wedge, tripod, MCOG ($125 P&S)	**$1599**

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4'', 8'', f/6 or f/10	**$249**
Giant EASY-GUIDER for 10''/12'' f/4-f/10 .	**$395**

MEADE STARFINDERS

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive (equat. only), mount, finderscope and 25mm (=48X) eyepiece.

6'' **f/8 Dobsonian Starfinder** ($46 P&S)	**$325**
6'' **f/8 Equat. Starfinder 6**(add $79 P&S) ...	**$599**
8'' **f/6 Dobsonian Starfinder** (add $59 P&S)	**$425**
8'' **f/6 Equat. Starfinder 8** (add $89 P&S) ..	**$699**
10'' **f/4.5 Dobsonian Starfinder** ($85 P&S) ..	**$595**
10'' **f/4.5 Equat. Starfinder 10** (add $99 P&S)	**$799**
12.5'' **f/4.8 Dobsonian Starfinder** ($95 P&S)	**$795**
16'' **f/4.5 Starfinder 16** (ship. freight COD) .	**$2495**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $99 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector .	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector with tangent arm & electric declination ..	**$475**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

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- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

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SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

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IMPROVED!—5500 Additions / Corrections

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Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER .	**$189.50**
2'' EASY-GUIDER (Mamiya 645)	**$239.50**
2'' Adapter for Pentax 6X7 ...	**$129.00**
2'' Adapter for Hasselblad .	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing ...	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$259.00**

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080 ...	**$119.50**
UV/Dust Deal for Celestron C-8 ...	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14 .	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$69.50**
LUMICON 2'' Helical Focuser 1½'' high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' **adapter** w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, right-angle	**$69.50**
1¼'' straight-thru 80mm SUPER-FINDER .	**$189.50**
1¼'' right-angle 80mm SUPER-FINDER ..	**$199.50**
1¼'' right-angle version, w/star diagonal ..	**$239.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$49.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc. ..	**$29.50**
2'' adapter for C-80, C-100 refractor ...	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

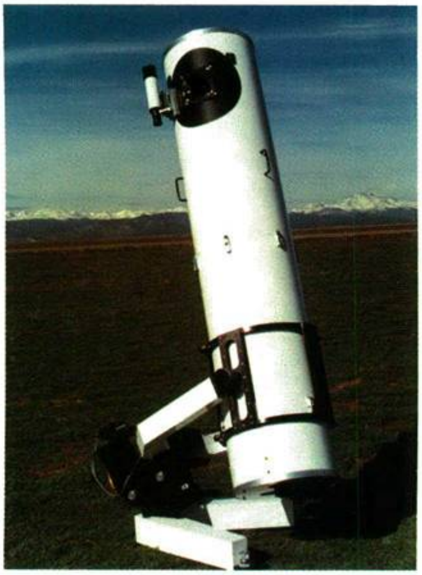
1'' long 1¼'' OD thread-in extension ...	**12.00**
2½'' long extension (holds 1¼'' filters) .	**19.50**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces* ..	**$29.00**
2'' long extension for 2'' eyepieces* ..	**$29.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$25.00**
2''/T-thread adapter, threaded 48mm* ..	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

New Products

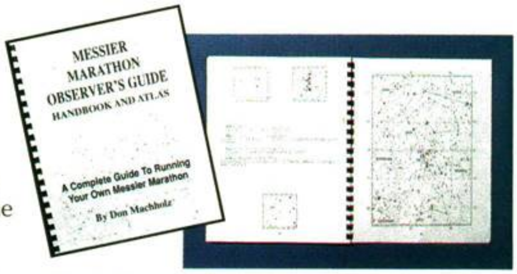


Portable 12½-inch Telescope

Constructed from lightweight composites, the Light Speed 12.5 weighs 108 pounds and breaks into five sections for easy transport. At its heart is a 12½-inch f/5.6 mirror with enhanced coatings that floats in an active, counterweight-articulated mirror cell similar to those found in professional observatories. The tube features 11 light baffles that enhance image contrast; area of obstruction from the secondary mirror is 17 percent. Light Speed's equatorial mount is fitted with a 9-inch clock gear and legs that fold for stowage. Its digital setting circles use 4,000-step encoders and come with a 10,000-object database.

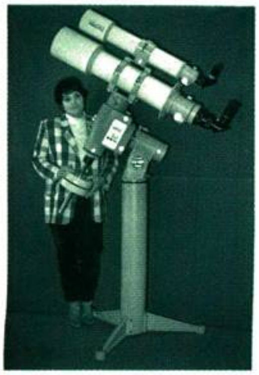
Light Speed Telescopes, 3991 Weld County Road 18, Erie, CO 80516, (303) 678-9547. Free fact sheet available upon request. Complete information package with color photos: $2. Light Speed 12.5: $7,895.

Messier Marathon Guide



Veteran comet hunter and deep-sky observer Don Machholz offers this guide to finding all the Messier objects in one night. The 100-page, spiral-bound guide divides into four sections. The first introduces the catalog and explains the nature of a Messier marathon. "Charles Messier and his Comets" gives background on Messier and his catalog's history. "The Messier Catalog" presents data on all 110 M-objects, which include galaxies, nebulae, and star clusters. "The Messier Marathon" surveys what it takes to mount a marathon and provides visibility charts, observing tips, and star charts. Rounding out the guide is a search sequence atlas that has finder charts placed in optimal order to see all 110 Messier objects during a single session in late March or early April.

Make Wood Products, P.O. Box 1716, Colfax, CA 95713, (916) 346-8963. $12.

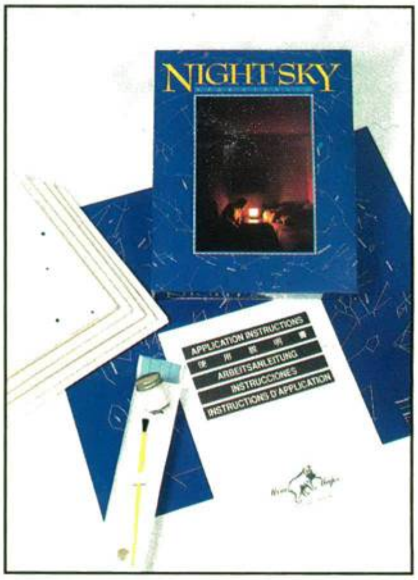


Telescope Mount

An ST4 autoguider plugs directly into Takahashi's new EM-500 German-equatorial telescope mount to automatically control right ascension and declination motors. The RA motor is reversible for use in the Southern Hemisphere and slews up to 16 times its normal drive rate; the declination motor slews to a maximum of 15' per second. Both motors are stepless and run off 12 volts DC. The mount also boasts a periodic error of 3.5" and can carry up to 84 pounds. The EM-500 is pictured with optional pier and telescope assemblies.

Texas Nautical Repair, 3110 S. Shepherd, Houston, TX 77098, (713) 529-3551, fax (713) 529-3108. EM-500 equatorial head: $8,125. Optional large pier: $1,516.

This department presents announcements issued by manufacturers. Product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers should send announcements and color photographs of their products to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.



Southern Sky for Ceilings

Add glow-in-the-dark southern constellations to any ceiling using the Night Sky Constellation Kit. You apply a non-toxic phosphorescent paint to a removable 7½- by 12-foot stencil to portray over 400 stars of the southern sky. Each kit includes a stencil, paint, brush, adhesive, star map, and instructions. Other constellation kits show the summer and winter skies for the Northern Hemisphere.

Ursa Major Corporation, P.O. Box 3368, 695 Mistletoe Rd., #2, Ashland OR 97520, (503) 482-1322, fax (503) 482-5597. Item 8SH: $25, plus $4.50 shipping and handling.

Telephoto Lens

Celestron has redesigned its 500mm f/5.6 telephoto lens to make it more ideal for astrophotographers. Multi-coated, Maksutov-Cassegrain optics provide virtually full illumination of a 35mm field and yield sharper images with higher contrast when compared to previous models. A T-adapter and tripod adapter are built into the lens' 43-ounce body. The lens comes with a soft case.

Celestron, 2835 Columbia Street, Torrance, CA 90503, (310) 328-9560, fax (310) 212-5835. Model #81005 telephoto lens: $578.

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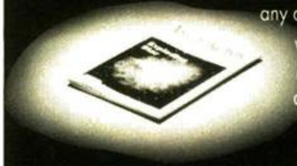

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NGC 253 image by Glenn Gombert & John Chumack ST-6 Camera

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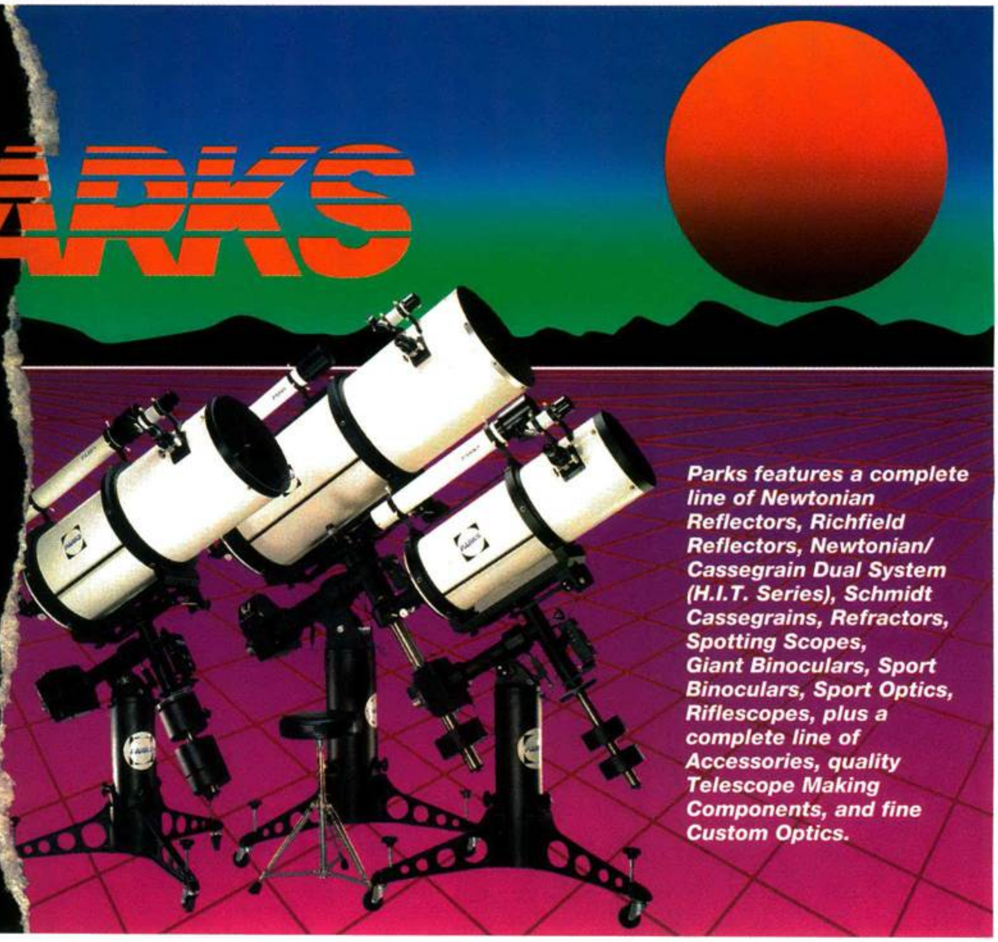

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#122 2x 1.25"	$43	Accy case 50	$67	Filter set of 8	$99	Off-axis guider	$80
#127 2-3x 1.25"	54	Car cord LX200	85	Filter set of 12	145	Piggy brkt 8/10"	32
#140 2x 1.25"	72	Diagonal 1.25"	42	Filter ND96 1.25"	18	Piggy brkt 12"	49
2045 Accy's:		Diagonal .96-1.25"	28	Illum 12mm w/cord	80	Reducer f:6.3	130
Barlow 126 2x	43	Diagonal .96" 45°	53	Illum 12mm-wless	100	Skylight/seal	48
Car cord	20	Diagonal 1.25" 45°	53	Illum 9mm w/cord	130	Tele extender	30
Carrying case	80	Diagonal 929 2"	100	Illum 9mm-wless	150	Tele ext-variable	40
Tripod & wedge	265	EP holder 1.25"	25	Lenshood 8"	114	T-adapt: vari-proj	40
Starfinder Accy's:		Focuser 70 1.25"	49	Lenshood 10"	124	Vari pol 905	50
Dust caps	call	Focuser 680 2"	100	Lenshood 12"	174	Weight set 8"	85
Dec 55	78	Focuser 682 2"	100	Nebula 908B	80	Weight set 10"	90
Drive 43 110v-12v	129	Finder 8x50	70	Nebula 908N	90	Weight set 12"	100
Drive 47M (6-8-10)	429	Finder 634-6x30	50	Nebula 911B	100	Wedge 8"	134
Drive 48RS (16")	499	Filter set of 4	55	Nebula 911N	120	Wedge 10" Super	395

Meade Series 4000	
Super Plossl 6.4, 9.7, 12.4, 15, 20, 26	$88
32 or 40mm	110
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Super Wide 18	170
Super Wide 24.5	199
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Ultra Wide 8.8	270
Ultra Wide 14	330

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NGF-3 Mini motor	179

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Meade 8"/10" SCT, 4"/5" APO, Starfinder 6"/8"/10" only $138
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Telrad

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		Ext tube	$33	**Plossl:**		**Panoptic:**	
		CXD-1 motor	234	7.4, 10.5, or 13	$ 70	15mm	$204
Genesis SDF	Call	Polar finder	119	17, 21, or 26	70	22mm	269
Pronto	Call	**Nagler:**		32 or 40mm	109	27mm	319
Renaissance	Call	4.8mm New!	168	55mm	224	35mm	354
Panoramic mt	349	7mm New!	216			Barlow interface	94
Gibraltar mt	449	9mm	234	**Wide Field:**			
Starbeam-T	179	12mm Type2	275	15mm	132	**Barlows:**	
Cam. adapter	39	13mm	275	19mm	140	1.8x	84
Piggycam	45	16mm Type2	299	**Paracorr 1.25"**	139	2.5x	84
Eyepiece proj	69	20mm Type2	368	**Paracorr 2"**	228	Big Barlow 2"	162

Sale!

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Large! 13x19x7" $50

Celestron		**Kendrick**	
C5+ w/wedge	Call	12v Controller	$59
C8+ w/wedge	Call	1.25"/2" heater	33
C5 tripod	259	8" heater	48
C5 fitted case	168	10"/11" heater	59
C5 lenshood	49	12" heater	68
Dew shield-8"	29	8" dew shield	43
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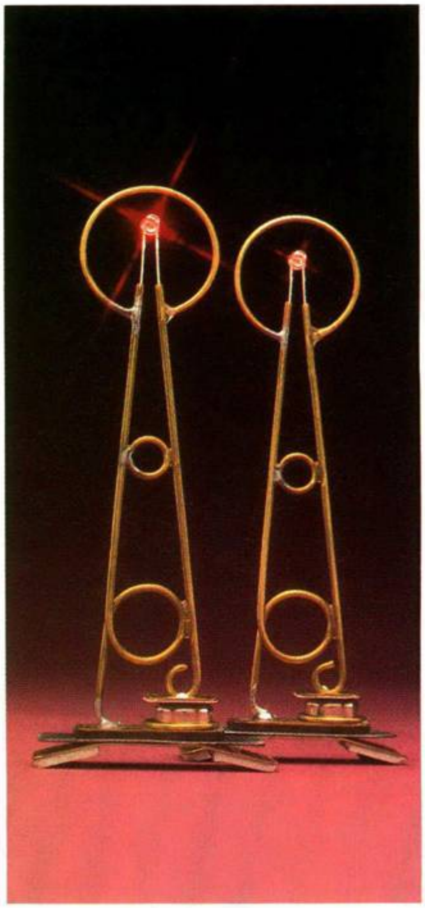

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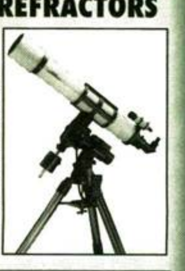

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GLASS (Full Aperture) Type 1

Made from high quality hand select glass, machine polished and **TRIPLE COATED** with a Nickel-Chromium alloy. Mounted in a machined aluminum cell ready to attach to telescope. Solar image is yellow-orange. No secondary filtering is necessary.

Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00

40mm to 80mm Binoculars - Mounted .... $92.00 pr.

GLASS (Full Aperture) Type 2

Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	129.00
11"	149.00	11"	139.00
12.5" to 13.1"	179.00	12.5" to 13.1"	159.00
14"	199.00	14"	179.00

40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS (Full Aperture) Type 3

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
6"	135.00	6"	115.00
8"	159.00	8"	139.00
10"	172.00	10"	152.00
11"	199.00	11"	179.00
12.5" to 13.1"	229.00	12.5" to 13.1"	209.00
14"	259.00	14"	239.00

Types 1 & 2 are for unlimited visual use and general photographic use. Instructions included with all filters, including tips on solar photography.

1/4 WAVE PREMIUM FILTERS

(Type 2 coating)

Aperture	Mounted	Aperture	Unmounted
2.4"	$129.00	2.4"	$119.00
3.1"	199.00	3.1"	189.00
3.5" to 4"	269.00	3.5 to 4"	259.00
5"	349.00	5"	339.00
6"	399.00	6"	389.00

Add $15.00 for Type 3 coating.

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ASTRO BOOKS

Duck and Cover

Rogue Asteroids and Doomsday Comets

Duncan Steel, (John Wiley & Sons, 1995), ISBN 0471-30824-2, 308 pages, hardcover, $24.95.

You're sitting around the dinner table after a meal with friends when all of a sudden one of them, a delightfully quaint English gentleman, lights up a pipe and leans back to spin yarns about his favorite subject. Rambling on in a lively and often opinionated way, the guest oftentimes leaves you wondering, "how did we ever get on this subject, anyway?" But the dissertation is harmless and at times very informative. At the very least, it's fun listening to someone so knowledgeable and articulate.

Metaphorical dinner table aside, that's exactly how *Rogue Asteroids* comes across. Here's British astronomer Duncan Steel's op-ed on what he feels is a clear and present danger. In a conversational and often circuitous way, he fully explores the risk posed to life on Earth by asteroids and comets that cross our orbit, and how we should address that risk. As the first chapter's title might seem to indicate, "Fiddling While Rome Burns," Steel is adamant of this threat.

He paints a solar system teeming with debris. A tour ensues of how the debris' very nature might help us get a handle on their actual number. Steel walks through some statistical assumptions that allow us to gauge the actual threat to Earth. He also details how an impact might affect our planet, both in the near and long term.

Steel talks of giant tsunamis, citing the discovery of coral remnants at several hundred feet above sea level as evidence of past impacts. Aside from the immediate thermal and concussive effects of a hit, there is ozone depletion, nitrogen poisoning of the atmosphere, and a variant of the "nuclear winter" scenario. Of course how acute these effects are depends on the impactor's size, angle of entry, whether the hit happens over water or not . . . all factors Steel meticulously examines.

Coupling these death-scenarios with a surplus of threatening asteroids, Steel analyzes your chances of dying from an asteroid impact versus, say, food poisoning. The odds of death-by-impact: 1 in 10,000; by food poisoning: 1 in 3 million. Believe it or not, you're less likely to die in a flood or an airplane disaster.

Even so, many might still consider a cosmic cataclysm remote. But the repercussions for life on Earth and the very reshaping of a planet's biosphere demand we take this threat seriously. If nothing else, maintains Steel, that should compel us to at least catalog near-Earth objects.

In his treatment of coherent catastrophism, Steel makes a strong pitch for the regularity of asteroid catastrophes. He singles out the Taurid meteor stream, associated with Comet P/Encke, as a likely — regular source of potentially dangerous projectiles. It was during the Beta Taurid shower of June 1908 that the Tunguska region of Siberia was leveled. More recently, in June 1975, lunar seismometers recorded hits on the Moon from objects of up to one ton.

Steel's most intriguing stand on this regularity of calamity is his linking of Stonehenge and the Pyramids to calamities in the skies. The shape of the Pyramids, Steel contends, reflects the enhanced cone-shape of zodiacal light when Earth's neck of the woods is full of Taurid Complex stuff. This happens, he extrapolates, every 5,000 years or so.

"I cannot say that I more than half-believe my speculations," he readily admits. His intention, he says, is to get an argument going on this matter to eventually arrive at the truth. So be it! (How did we get on this subject anyway?)

This kind of quirkiness makes *Rogue Asteroids* a refreshing read. In one fell swoop, while the Comet Crash of '94 is still fresh in everyone's minds, Steel looks at the whole issue of asteroid and comet impacts on Earth, be they past events, present dangers, or future threats. — *John Shibley*

(Review the first chapter and table of contents of *Rogue Asteroids* on the Internet at: http://dab.psi.net/chapterone/astronomy)

More New Books

Bad Astronomy

Linda Zimmerman, (Linda Zimmerman, 1995), ISBN 0-9645133-07, 213 pages, softbound, $19.95. Available from Linda Zimmerman, P.O. Box 487, Piermont, NY 10968.

Before we reaped the benefits of 20th-century hindsight, there were a lot of strange versions of reality floating around.

(continued on page 100)

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Barlow Lens (1.25") ★ Series 3000 Plossl Eyepieces (1.25"): 5mm, 6.7mm, 9.5mm, 16mm, 25mm, 40mm ★ **Modified Achromatic Eyepieces (1.25" & .965"):** ★ 9mm ★ 12mm ★ 25mm ★ 40mm **Barlow Lenses (1.25" & .965"):** ★ #122 2X Telenegative (1.25") ★ #126 2X Short-focus (1.25") ★ #127 2X-3X Var. (1.25") ★ #134 2X Achromatic (.965") **Basic and Var. Proj. Camera Adpt.:** ★ Basic (.965") ★ Basic (1.25") ★ Var. Proj. (1.25") **T-Mounts (T-Rings) for:** ★ Canon ★ EOS ★ Contax ★ Fujica X ★ Konica ★ Minolta ★ Maxium ★ Nikon ★ Olympus ★ Pentax (thread & K) ★ Petri **Schmidt-Cassegrain Photographic Adpt.:** ★ #62 T-Adpt. ★ Basic Tele-Extender ★ Var. Tele-Ext. ★ Off-Ax. guider and f/6.3 Focal Reducer/Fld. Flattener **Illuminated Reticle Eyepiece Sys.:** ★ Plossl 9mm (1.25") wireless ★ Plossl 9mm (1.25") w/ cord ★ MA 12mm (1.25") wireless ★ MA 12mm (1.25") w/cord **Series 4000 Photo-Visual Color Filt. (1.25")** ★ #8 Lt Yellow ★ #11 Yellow-Green ★ #12 Yellow ★ #21 Orange ★ #23A Lt Red ★ #25A Red ★ #38A Dark-Blue ★ #47 Violet ★ #46 Lt Green ★ #58 Green ★ #80A Blue ★ #82A Lt Blue ★ Set #1 (#12, #23A, #58, #80A) ★ Set #2 (#11, #25A, #47, #82A) ★ Set #3 (#8, #21, #38A, #56) ★ Sets #1 & 2 (8 - Filt.) ★ Sets #1 & 2 & 3 (12 - Filt.) ★ Series 4000 Moon Flt.: ND96 ★ #905 Var. Pol flt. (1.25") **Series 4000 Nebular Filt.:** ★ #908N, 910N, 911N (rear cell thread) **30mm & 50mm Viewfinders:** ★ #637 6x30mm wht. tube w/bkt. ★ #545 8x50 wht. tube w/o bkt. ★ #544 8x50 blue w/o bkt. ★ Dovetail bkt. for 8x50 VF **Image Erect. Sys.:** ★ #921 Strght-thru Er.-Im. Porro Pr. (.965") ★ #924 Strght-thru Er.-Im. Porro Pr. (1.25") ★ #927 45° Er.-Im. Dia. Pr. (.965) ★ #928 45° Er.-Im. Dia. Pr. (1.25) ★ #9317 45° Hy. Er.-Im. Dia. Pr. (.965/1.25") **Diagonal Prisms & Mirrors:** ★ #915 90° Dia. Pr. (.965) ★ #917 Hybrid Dia. Pr. (.965/1.25") ★ #918A Dia. Pr. (.1.25) ★ #929 2" Dia. Mirror (1.25"/2") ★ #930 2" Dia. 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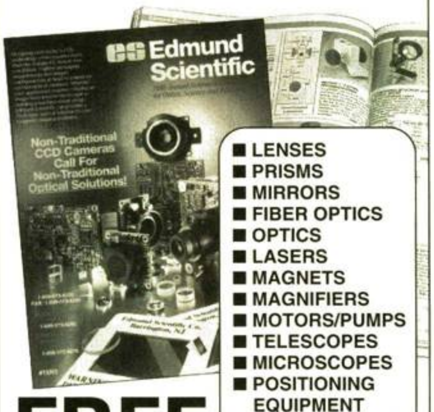
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ASTRO BOOKS

Those great thinkers, the ancient Greeks, are often good for a laugh or two these days, now that we know better, right?

Well, Linda Zimmerman has culled history for strange stories from the annals of weird astronomy. Written in the spirit of Joseph Ashbrook's *The Astronomical Scrapbook* (Sky Publishing, 1984), *Bad Astronomy* lays bare all the misconceptions of our intellectual forefathers, from the ancient Greeks to the not-so-far-removed scientist who, in 1952, offered 25,000 German Marks to anyone who could prove the Sun's interior was a massive greenhouse.

Through Zimmerman we read of Herakleides of Ephesus (born 544 BC), who figured the Sun, at one foot in diameter, was composed of rising vapors set alight by some unknown mechanism. There's 16th-century Protestant reformer Martin Luther, who thought Copernicus was an "upstart astrologer" wishing to "upset the whole science of astronomy." And the 18th-century discoverer of Uranus, William Herschel, who showed London bluebloods views of planet-shaped lanterns through his telescope on cloudy nights, passing them off as the real thing.

Bad Astronomy is full of many more such stories, guaranteed to leave you wondering how humans ever made it into the space age. But then again, can you imagine what the Sun's motion through our sky would look like if Earth were indeed at the center of the universe?

Extraterrestrial Intelligence

Jean Heidmann, (Cambridge University Press, 1995), ISBN 0-52145340-2, 235 pages, hardcover, $24.95.

Today astronomers have stated openly that they hope to find Earth-sized planets around other stars within the next 20 years. Running in tandem with this effort are radio telescopes that search millions of radio frequencies at once, looking for repeating, artificially produced blips that might betray the presence of an extraterrestrial civilization. In our lifetimes, we might glean hard evidence for such sentient life or, if Earth-sized planets are found, better the odds that such life exists.

Extraterrestrial Intelligence is a primer for our time. First published in 1992 by French author Jean Heidmann, this 1995 English translation ventures into all facets of the extraterrestrial life issue.

Heidmann examines what chemical, biological, and physical prerequisites must be met if even the most basic of life is to get a toehold anywhere in the universe. What are the chances of life elsewhere in our solar system, on Mars or in comets? What about within "habitable zones" around stars?

He also considers what might constitute intelligent life and how the only intelligent life we know of in the universe, humans, is trying to find evidence that they are not alone. What are the ramifications when mankind finally lands such evidence? How and by whom should the official announcement be made?

In short, concise sections, Heidmann looks at all these issues, each laid out in a form that is easy enough to browse through one topic at a time.

The Greatest Adventure

Edited by Edward Gibson, (C. Pierson, 1994), ISBN 0-947068-19-8, 224 pages, hardbound, $39.95. Available from Publishers Group West, 4065 Hollis, Emeryville, CA 94608.

This resplendent, oversized book is printed on high-quality, semi-gloss paper and follows up the immensely popular *The Home Planet* published almost ten years ago. But where *The Home Planet* dealt mainly with astronaut experiences of seeing Earth from afar, *The Greatest Adventure* focuses squarely on the sights, sounds, and feelings of flying in space. To accomplish this, several dozen astronauts and cosmonauts share their journeys in photos, many of which never published, and stories, some never before told.

At times the recollections are very personal and moving. A letter to Mercury astronaut Scott Carpenter from his dad on the eve of Carpenter's flight resonates with the pride and envy every father feels for a son's accomplishments. During a 1991 flight on Mir, Austrian cosmonaut Franz Veiböck describes his on-orbit view of a battle in the former Yugoslavia to his Croatian-born wife via radio. Running with Veiböck's narrative is a photo he snapped of the battle zone's smoke drifting out over the blue Adriatic.

Other, less haunting photos splash throughout the 12½- by 9-inch book. *Greatest Adventure* excels at this, drawing upon the largely untapped photo resources of the Shuttle program and Russian Salyut/Mir flights. There's also plenty of seldom-seen imagery from manned space flights during the 1960s and 70s. *Greatest Adventure* makes for an enjoyable browse, if not for the words, then for the pretty pictures. ☐

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MEETINGS & EVENTS

September 2
Island Lake Star Party, Brighton, Michigan. Contact The Ford Amateur Astronomy Club, P.O Box 7527, Dearborn, MI 48121-7527, (313) 390-5456.

September 15-17
Astrofest, near Kankakee, Illinois. Contact Astrofest, P.O. Box 596, Tinley Park, IL 60477-0596, (312) 725-5618.

September 16
Long Island Astro Forum, Greenvale, New York. Contact Ron Rizzi, (516) 795-3072.

September 20-23
Twin Lakes Star Party, Golden Pond, Kentucky. Contact Jim Boren, 262 Shane Lee Circle, Dover, TN 37058, (615) 232-6820.

September 21-24
Great Plains Starfest, Kansas Flint Hills, Kansas. Contact Bob Nederman, 9200 Westerbrooke Drive, Overland Park, KS 66214.

September 22-23
Dark Sky Observing Party, Panaca, Nevada. Contact Jim Mellor, 7470 Schirlls Street, Las Vegas, NV 89139, (702) 361-1356.

September 22-23
East Coast Star Party, Coinjock, North Carolina. Contact Kent Blackwell, 1169 Old Kempsville Road, Virginia Beach, VA 23464.

September 22-24
Connecticut Star Party, Colebrook, Connecticut. Contact Joel Marks, P.O. Box 5032, Milford, CT, (203) 874-4816.

September 22-24
Fall Equinox Star Party, Louisville, Kentucky. Contact David Shields, 850 Otter Creek Park Road, Brandenburg, KY 40108-9727, (502) 583-3577, ext. 105.

September 22-24
Nightfall, Borrego Springs, California. Contact Nightfall, Fox & Stephens, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730, (909) 948-2205.

September 23
Blue Ridge Parkway Regional Stargaze, near Blowing Rock, North Carolina. Contact Greg Kirby, 5026 Poplar View Lane, Granite Falls, NC 28630. □

RESOURCES & PHOTOFACTS

Fires at Cosmic Dawn (page 36)

Lonely Hearts of the Cosmos, by Dennis Overbye (HarperCollins, 1991) surveys cosmology and in the process reviews research on quasars. Various theories about the origin and evolution of quasars spread throughout the search for the origin and fate of the universe.

Quasar Astronomy, by Daniel Weedman (Cambridge University Press, 1986) presents a technical volume for those seriously interested in quasar research. Chapters explore the technology required to study quasars, surveys to discover quasars, quasars as cosmological probes, and the structure and significance of quasars.

Light Pollution (page 44)

The International Dark-Sky Association is the best source for information about light pollution and on what it takes to make a difference. Contact them at IDA, Inc. 3545 N. Stewart, Tucson, AZ 85716.

Needles in the Cosmic Haystack (page 50)

"A Brightening Star Reveals Dark Matter," by Wallace Tucker, ASTRONOMY, August 1994. Describes searches for dark matter in the Galaxy called MACHOs (massive compact halo objects), which may include brown dwarfs. Updates on MACHO searches are found on the Internet at http://meteor.anu.edu.su/~pjq/macho.html and at http://www. astrow.edu.

Tune Up Your Telescope for CCD (page 66)

Choosing and Using a CCD Camera, by Richard Berry (Willmann-Bell, 1992) surveys the process of using a CCD camera in the field. It presents extensive how-to information on the techniques required to record clean, satisfying images.

Introduction to Astronomical Image Processing, by Richard Berry (Willmann-Bell, 1991) contains a exhaustive guide on using the computer as a darkroom, detailing image enhacement techniques.

Spotlight on Saturn's Satellites (page 72)

"The Vanishing Rings of Saturn," by Julius Benton and Richard Talcott, Astronomy, June 1995. Describes in detail what backyard observers can see of Saturn and its rings around the time of ring-plane crossing.

Big Sky Deep-sky (page 76)

The Milky Way, by Bart J. Bok and Priscilla F. Bok, (Harvard University Press, 1981). Provides the best overview of our Milky Way's components and structure.

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pp. 66-71: all images by Gregory Terrance, using an SBIG ST-6 or an SBIG ST-5 CCD camera for the deep-sky images and a Spectra-Source Lynxx PC CCD camera for the planetary images; **p. 67, top and bottom:** 8-inch f/5 reflector; **p. 68, top left and bottom:** 8-inch f/5 reflector; **top right:** 8-inch f/9 refractor; **p. 69, top:** 8-inch f/5 reflector; **bottom:** 8-inch f/5 reflector; **p. 70, top and bottom:** 8-inch f/5 reflector; **p. 71, top:** 8-inch reflector; **bottom:** 8-inch f/9 refractor; **p. 72:** Donald C. Parker, 16-inch f/5 reflector and Spectra Source Lynxx CCD camera, taken on May 15, 1995; **p. 77, background:** Alan Dyer, Orion area, 50mm lens @ f/1.8, Ektachrome 1600 shot at ISO 400, 12 minutes slightly diffused with a fog filter for 6 minutes; **right:** Luke Dodd, M78, Pentax 6x7 camera using hypered Fujicolor 400, 60 minutes ; **bottom left:** Bill and Sally Fletcher, M42, 8-inch f/4.5 reflector, tri-color composite image that uses Kodak TP2415 film shot through a red filter for 60 minutes, green for 15 minutes, and blue for 115 minutes; **bottom right:** Mike Sisk; **p. 78:** Gerald Rhemann, 400mm f/4 refractor, a composite of two 40-minute exposures, hypered Fujicolor NHG 400; **p. 79:** George Greaney, 6-inch f/7.1 refractor, a composite of two 50-minute exposures, hypered Fujicolor SHG 400; **p. 109, top:** Glenn Gombert and John Chumack, 6-inch f/4 reflector, SBIG ST-6 CCD camera, taken April 4, 1995; **bottom:** Don Parker, 16-inch f/5 reflector, SpectraSource Lynxx PC CCD camera, taken May 13, 1995 at 12:57 a.m. EDT; **p. 110:** Gerald Rhemann, 8-inch Schmidt camera, hypersensitized Kodak Ektar 25 film, composite image of two 20-minute exposures; **p. 111, top:** Alberto Levy, 16mm lens at f/4, Fujichrome 400 film, 20-minute exposure taken at the National Observatory, San Pedro Martia, Baja California, Mexico; **middle:** Jack Newton, 25-inch f/5 reflector, Meade Pictor 1616 CCD camera; **bottom:** James R. Foster, 180mm lens at f/5.6, hypersensitized Fuji Super HG 400 film, composite image of 80- and 60-minute exposures; **p. 112:** Douglas C. Zubenel, 16mm f/2.8 fisheye lens, Fuji Super G 400 film, 20-minute exposure taken March 20, 1995, from near Kansas City, Kansas □

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READER REPORTS

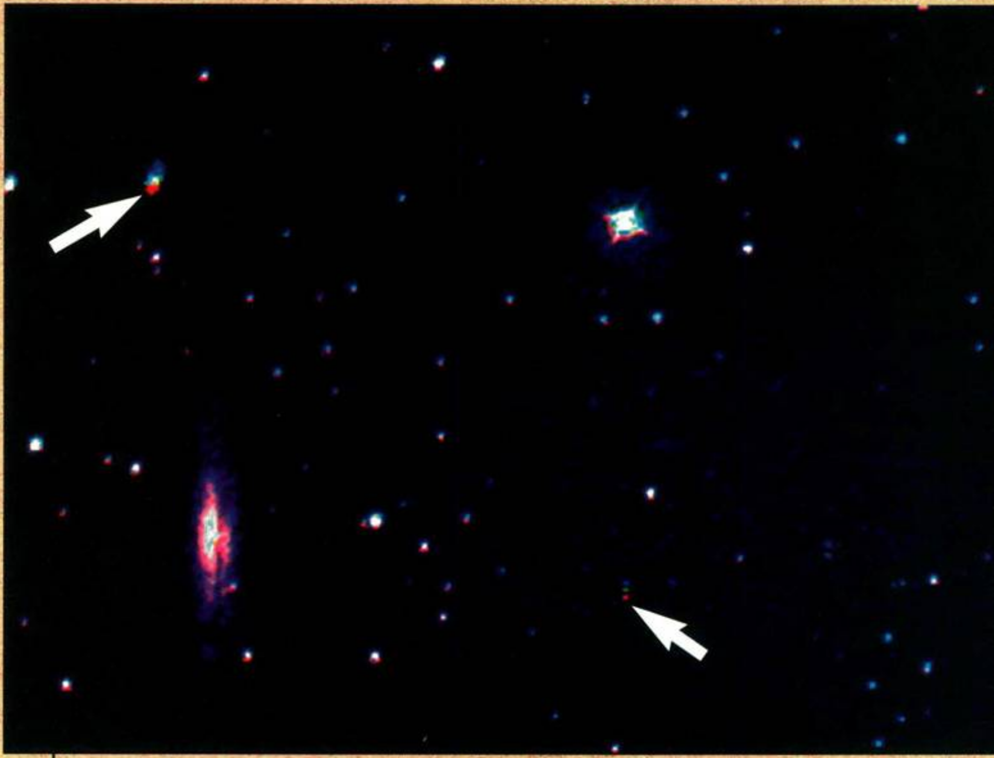
Two for the Price of One

CCD imagers Glenn Gombert and John Chumack of Dayton, Ohio, got more than they bargained for when they set out to record the asteroid 9 Metis this past spring. On April 4, 1995, the asteroid moved past the edge-on galaxy NGC 3628 in Leo. Metis appeared as a 10th-magnitude "star" that glided parallel to the galaxy during the first few days of the month.

"We thought it would make an easy target for our SBIG ST-6 CCD camera," says Gombert. The pair used Gombert's 6-inch f/4 reflector to maximize the field of view. They wanted to fit not only 9 Metis and NGC 3628 within the frame but also the nearby galaxies M65 and M66.

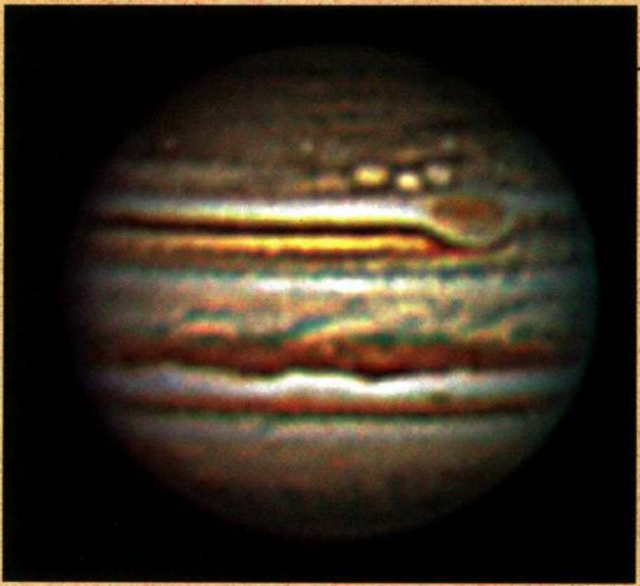
"We took black-and-white and tricolor exposures of the field," says Gombert. Because the frame for each of the three colors is made at a different time, the tricolor images show the asteroid's motion as a line of red, green, and blue dots. "Not only did we image NGC 3628 and 9 Metis in the field, but also a part of the galaxy M65 and the fainter asteroid 953 Painleva. It was two asteroids for the price of one.

Meteor Observations. George Zay of La Mesa, California, spent several days in April and May 1995 monitoring the Eta Aquarid and Lyrid meteor showers. "The weather dealt most people a bad hand for the Lyrids," says Zay, "but my friend Robert Lunsford and I were successful." On the night of April 21/22 they spotted 17 Lyrids and 31 sporadics over 7⅓ hours. The two brightest



Asteroids 9 Metis (left arrow) and 953 Painleva Pass NGC 3628

by Glenn Gombert and John Chumack
(6-inch f/4 reflector, SBIG ST-6 CCD camera, taken April 4, 1995)



Jupiter and Its White Ovals

by Donald C. Parker
(16-inch f/5 reflector, SpectraSource Lynxx PC CCD camera, taken May 13, 1995 at 12:57 a.m. EDT)

Lyrids blazed at magnitudes –6 and –3. The brightest one left a train that remained visible for about eight seconds. Zay's average magnitude for the shower was an impressive 0.8 — the average sporadic streaked across the sky at magnitude 2.

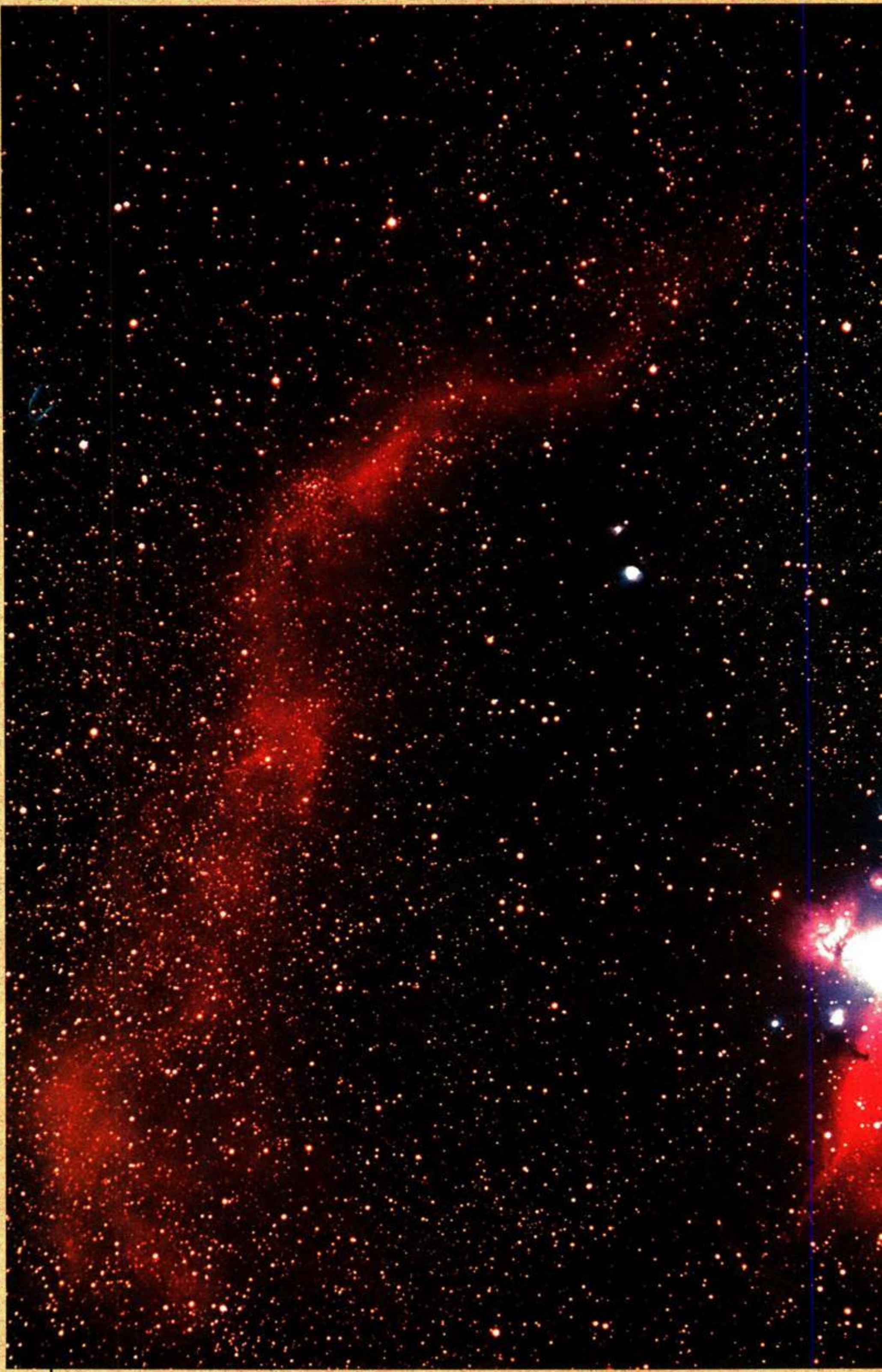
Zay started observing Eta Aquarids on April 27/28. After a stretch of rain, the skies cleared and allowed him to observe on May 8/9, 10/11, and 11/12. Eta Aquarids began to appear by April 28 if not sooner, according to Zay. Rates averaged about three to four per night through May 2, when the numbers increased to about 15 observed shower members over a 2½-hour period.

On May 11, Zay noted a decline in the numbers and by the next night, "it was clear the 1995 Eta Aquarids were over." The brightest meteors Zay saw during the campaign were two –3-magnitude meteors during the morning of May 9 and a –4-magnitude sporadic on the 12th. All had a greenish tint.

Venus Orbits the Sun. "Last November, my 13-year-old daughter and I completed a project of viewing Venus through an entire orbit by making daylight observations," says Phil Dombrowski of Glastonbury, Connecticut.

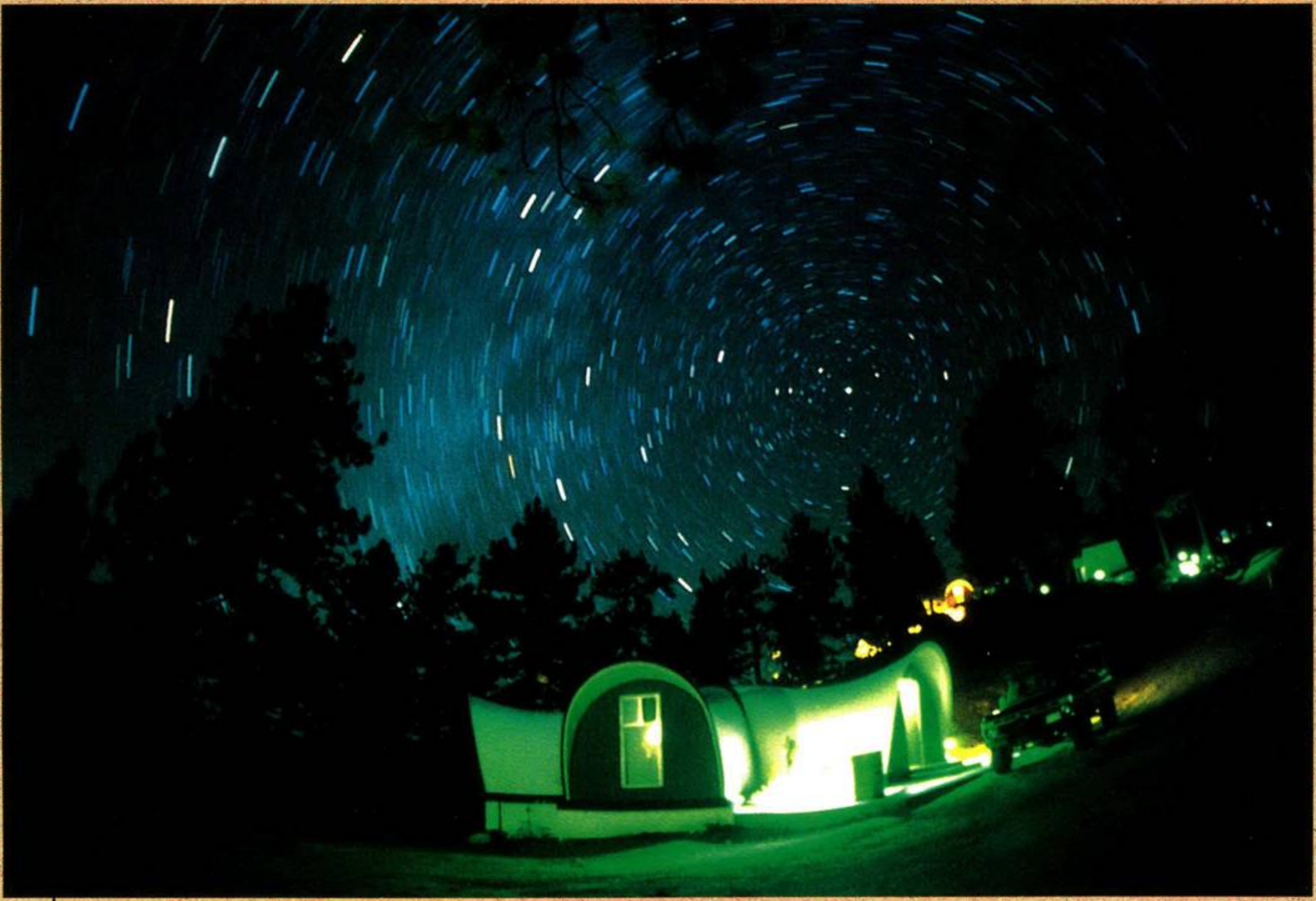
"I encourage others to try this project," he says. "We used an 11-inch SCT and observed the planet only 18 hours past inferior conjunction. It's a delight to see the planet while the Sun is in the sky." ☐

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Please label each photo with name, address, and social security number. You may send written reports via the Internet to: rreports@astronomy.com



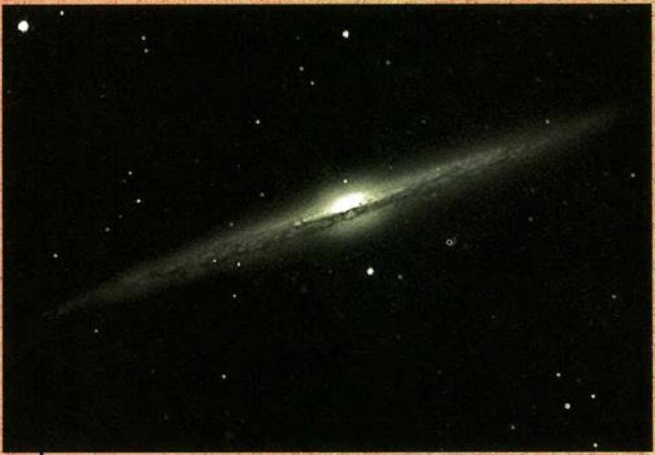
Barnard's Loop and Central Orion

by Gerald Rhemann
(8-inch Schmidt camera, hypersensitized Kodak Ektar 25 film, composite image of two 20-minute exposures)



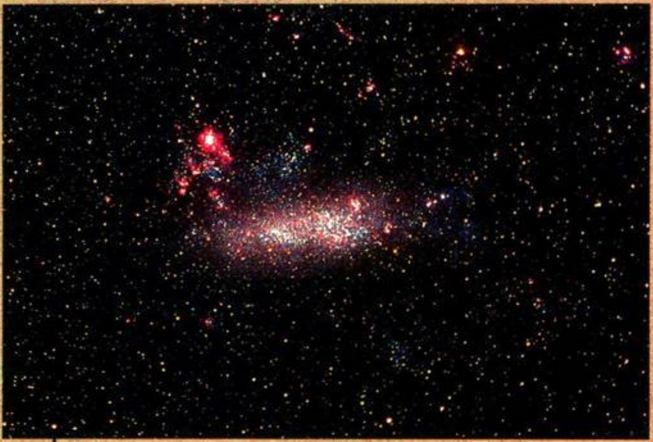
Stars Trail Over Sierra San Pedro Mártir, Baja California, Mexico

by Alberto Levy
(16mm lens at f/4, Fujichrome 400 film, 20-minute exposure taken at the National Observatory, San Pedro Mártir, Baja California, Mexico)



Edge-on Galaxy NGC 4565

by Jack Newton
(25-inch f/5 reflector, Meade Pictor 1616 CCD camera)



The Large Magellanic Cloud

by James R. Foster
(180mm lens at f/5.6, hypersensitized Fuji Super HG 400 film, composite image of 80- and 60-minute exposures)

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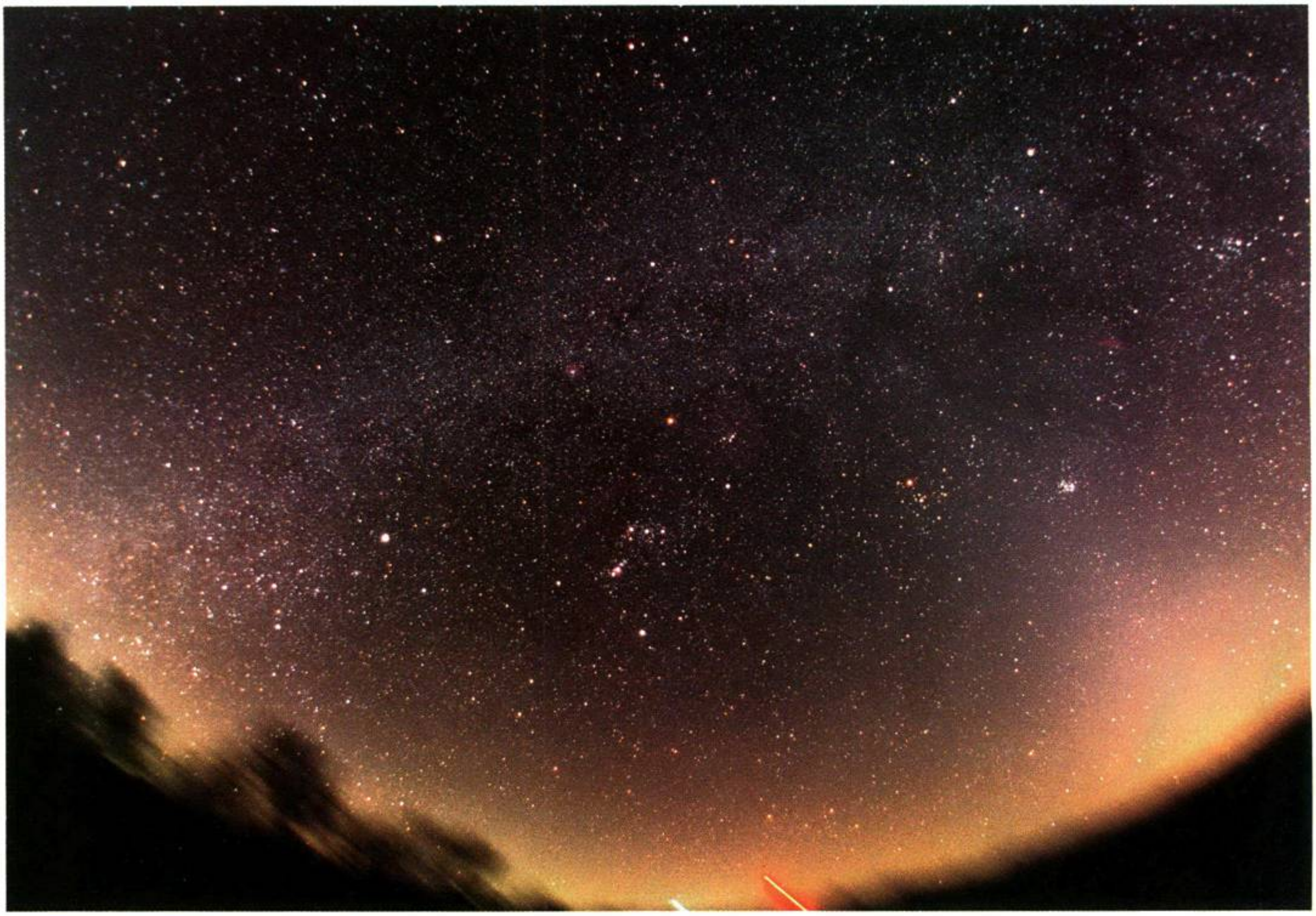
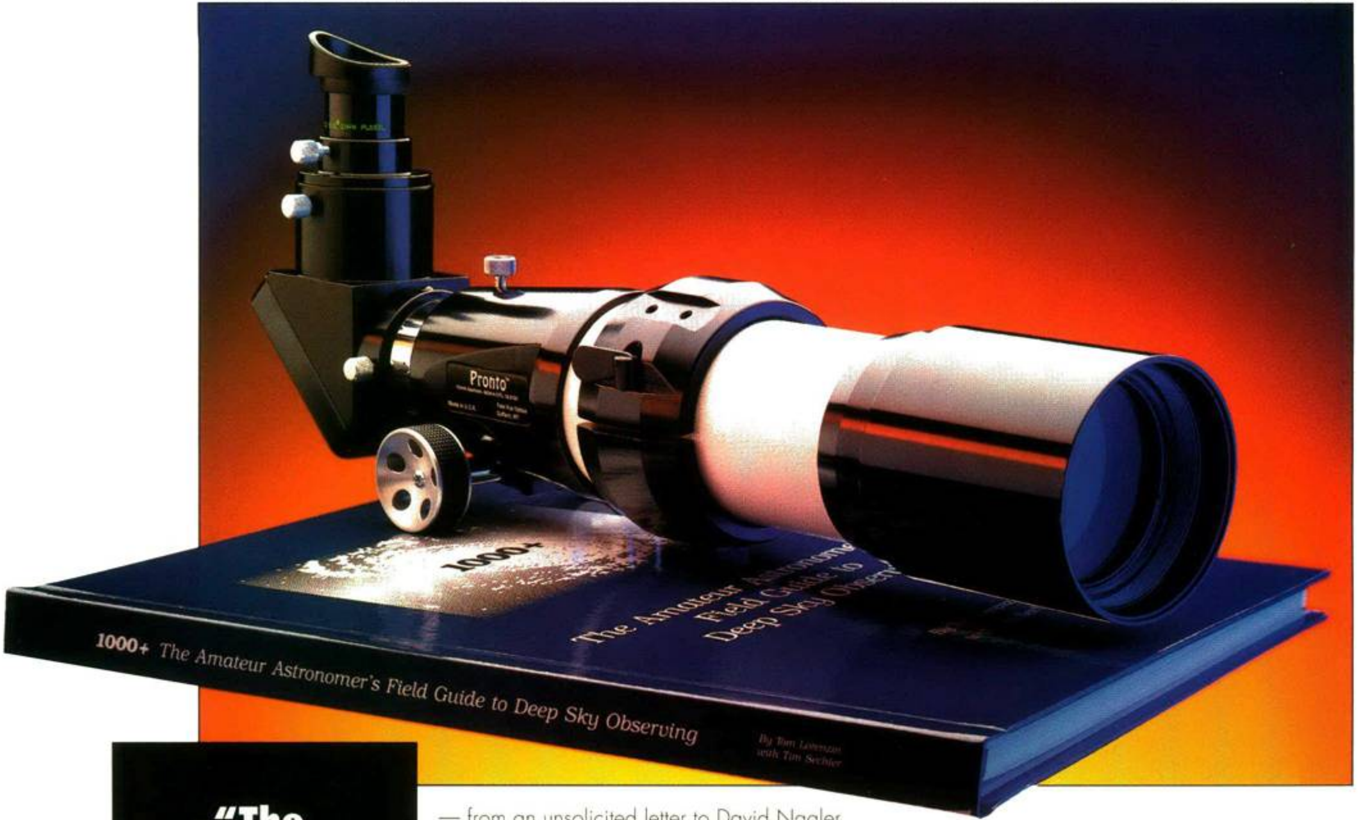


Zodiacal Light Graces the Winter Milky Way

by Douglas C. Zubenel
(16mm f/2.8 fisheye lens, Fuji Super G 400 film, 20-minute exposure
taken March 20, 1995, from near Kansas City, Kansas)

Pronto: 70mm Ap., 480mm F.L., f/6.8 E.D. doublet, 2" diagonal, 21mm Plössl, adapter, mount ring, shoulder bag std.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1000+ The Amateur Astronomer's Field Guide to Deep Sky Observing
By Tom Lorenzin with Tom Sechler

"The Little Scope That Did."

— from an unsolicited letter to David Nagler

"I bought my Pronto in January '91. Ever since, I have enjoyed great views, whether it be deep sky, the planets, or with the proper filter, our sun. I've seen several ads about the Pronto describing it as 'the little scope that could.' Let me tell you about 'the little scope that did!'

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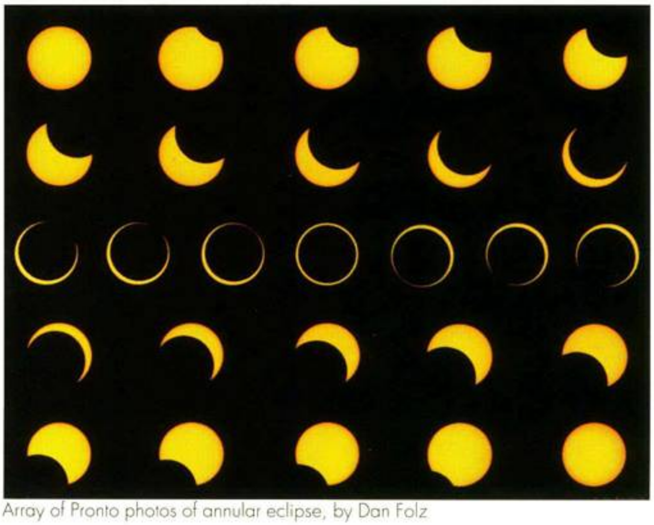
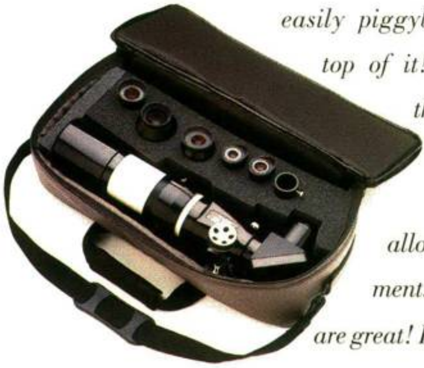
Best regards and clear skies, — Dan Folz, IL



Array of Pronto photos of annular eclipse, by Dan Folz



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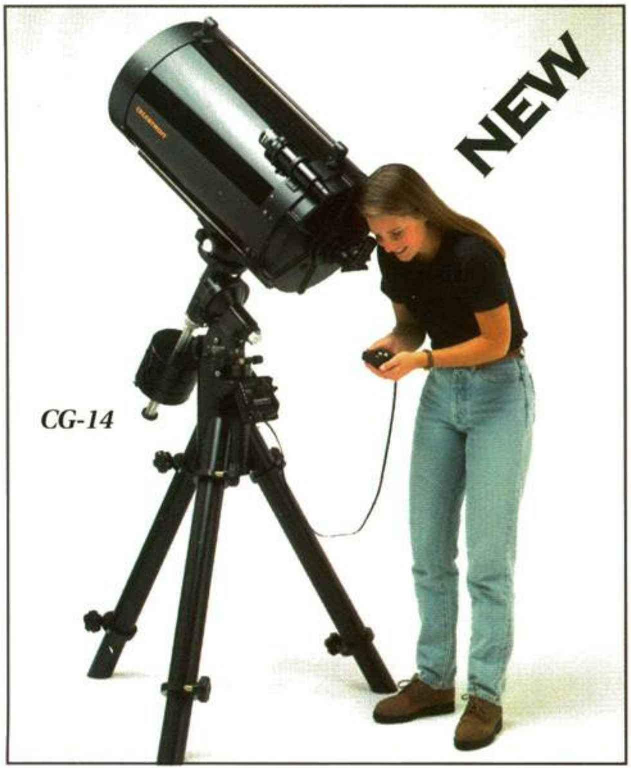

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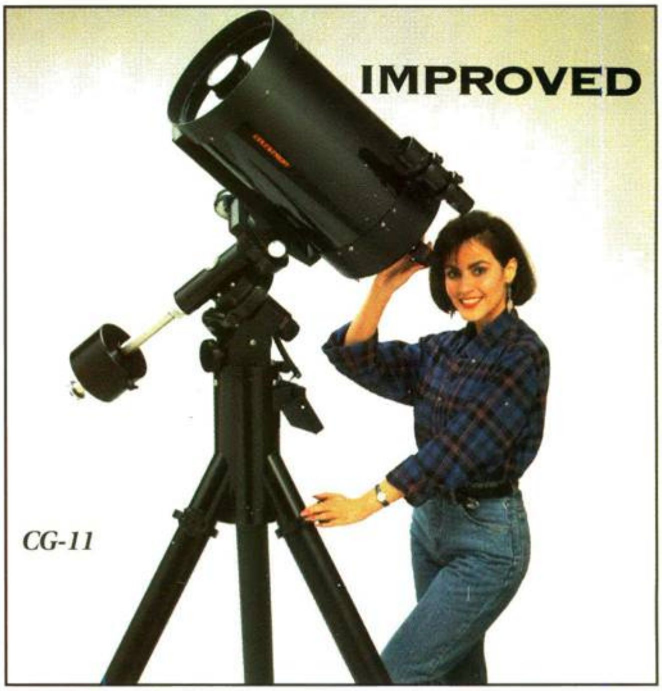

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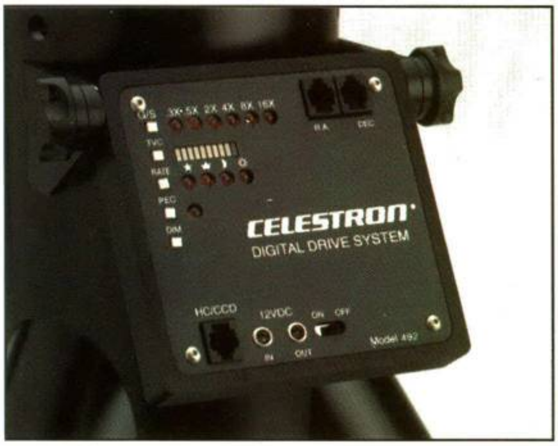

G-11 Electronic Panel

The G-11's dual axis DC electronics are state-of-the-art. Four tracking rates are available: Sidereal, King, lunar and solar. It has three setting rates of 4x, 8x and 16x. Also it has three photo guide rates of ±30%, ±50% and 2x. The electronics have full feature PEC (Periodic Error Correction) built-in. TVC (Time Variable Constant) built-in is a user programmable declination backlash compensation for instantaneous tracking response. *Sky & Telescope* said, "the drive is so accurate that tracking was superb whether or not the electronic PEC feature was switched on."

For more detailed information on these telescopes, contact your Celestron dealer or Celestron.

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